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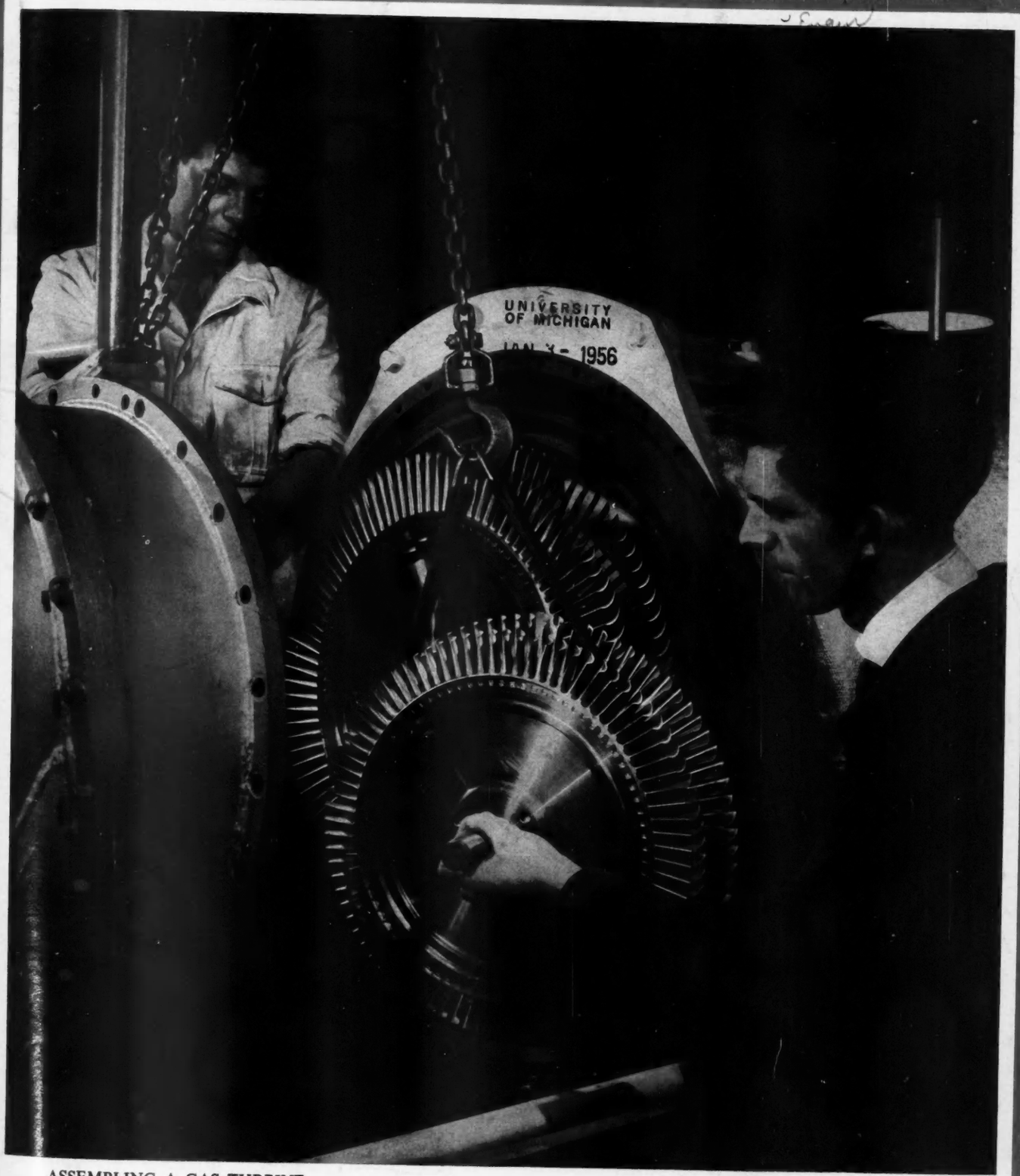

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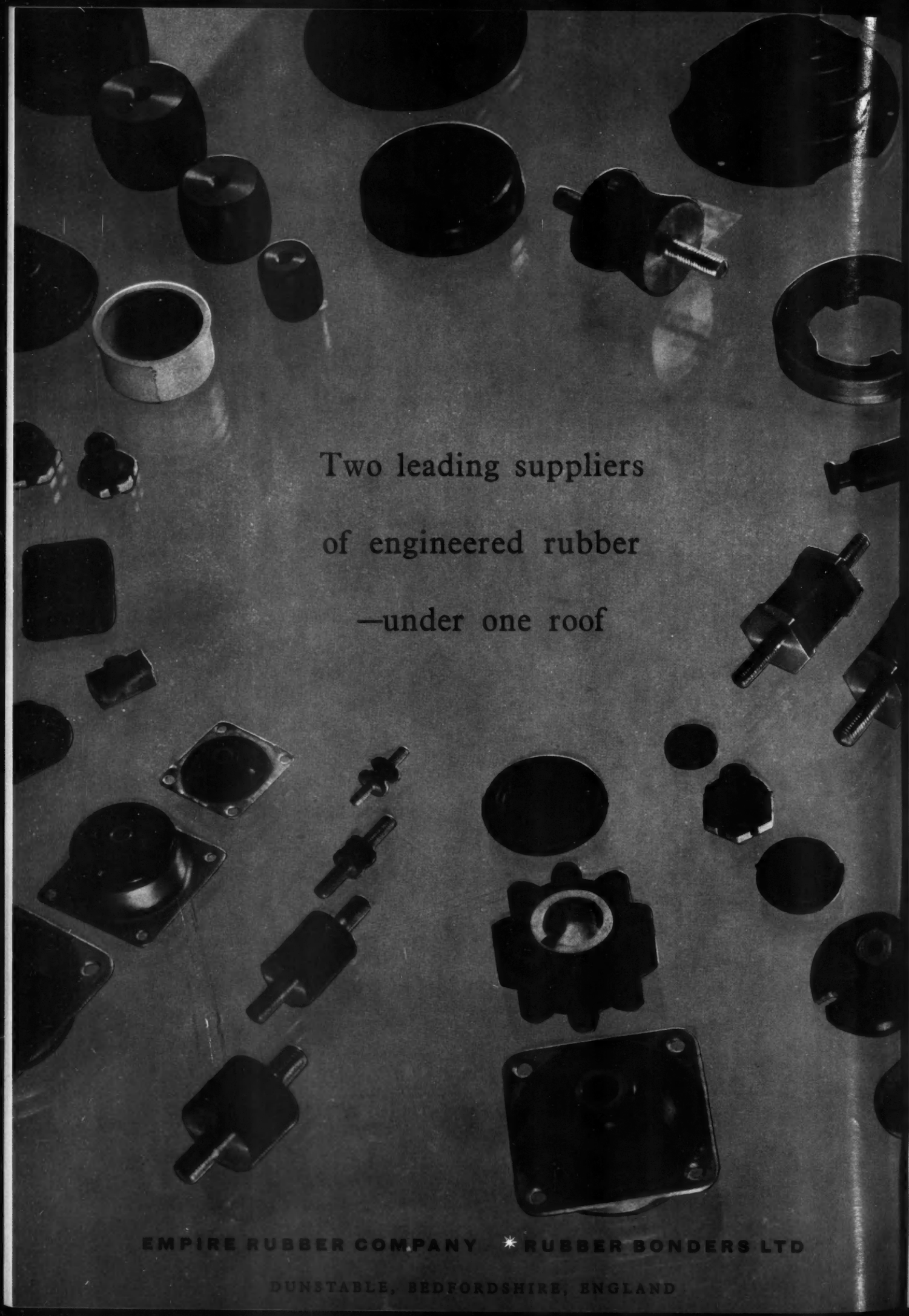
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ENGINEERING

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Vol. 180 No. 4689 DECEMBER 9, 1955

Leading Article

The Pendulum Swings 777

Weekly Survey

Engineering in the Van 778
Aluminium in Short Supply 778
Machines on the Farm 778
Iron Castings Output 778
Australia Takes a Chance 778
Independent Air Operators' Dilemma 779
Competition from the French 779
Penny Plain, Twopence Coloured 779
Vote of Confidence 779

Principal Articles

Television in Colour: Experimental Equipment for the B.B.C. 780
Some Aspects of the American Aircraft Industry: (1) Activities of the Major Constructors 787
High Pressures: Properties of Matter and Design of Equipment 789
Adhesive Weight Reduced by Effects of Traction Forces: Design of Electric Bogies for Locomotives 791
Polarographic Research Laboratory: Apparatus for Rapid Chemical Analysis 795
Controlling Hydraulic Power: Use of Accumulators in Heavy Industry 796
Valve Spring Failures: Methods of Improving Fatigue Endurance 797
The Iron and Steel Institute: Examining the Inside of a Furnace: B.I.S.R.A. Scanning Telescope 798
Aluminium Extrusion Factory: Production Plants Housed in the Product 799
Dispersion of Dangerous Gases 801
The World's Largest Oil Tanker: "Spyros Niarchos" Launched at Barrow 802
Continuous Heat Transfer Apparatus: Laboratory to Investigate New Applications 803
Motor Grader Operation Extended: Attachment for Loading Spoil 803
Power for the Future: First Meeting of Nuclear Energy Conference 805

Letters to the Editor

Scientific Methods in the Army 783
Public Technical Libraries 783
Ultimate Strength of Thick-Walled Cylinders 783
Developing a Design 783

Obituary

Major K. Gordon, C.B.E., M.C. 782
Mr. F. H. Rogers 782
Lt.-Col. G. T. Bennett, M.B.E. 782

Book Reviews

An Illustrated History of Science 785
Dry Dust Suppression and Percussive Drilling 785
General Mechanical Drawing 785

Notes

Institute of Metals: Nuclear Energy Committee 782
Television at Pontop Pike 790
Mobile Excavators: Lorry-Mounted Vehicles 803

In Parliament 807

The Human Element 808

Personal 784, Commercial 784, Contracts 784, Books Received 786, Trade Publications 786, Launches and Trial Trips 802, Notices of Meetings 806

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THE PENDULUM SWINGS

THE Legal Aid and Advice Act 1947 was designed for the man at the lathe or grindstone—the man of limited means. It now enables the poorer person to wage costly legal action, and the fact that in the ordinary course of events he could not find a fraction of the money spent on his behalf does not deter or worry him at all; for either the State's legal aid fund or his forensic adversary will pay the bill. The need for the statute was apparent, for as soon as the Bill became an Act the courts were deluged with an influx of legally aided litigants, many of them injured workers suing their employers for injuries sustained at work. Undoubtedly the scheme has been and is of great social benefit, but it cannot be overlooked that it has been abused by the few.

To obtain legal aid an applicant has only to show that he has a *prima facie* case for a legal aid certificate to issue. An accident at work is usually sufficient, and this has caused the unscrupulous to "try it on." And not only the unscrupulous; the average British employee considers himself entitled to compensation if anything in the way of an accident happens to him at work, even though the mishap be caused by his own negligence. This attitude is illustrated by two recent cases, in which workmen were injured through disobeying their employers' instructions. In one case the injured man was foolish enough to clean the roller of a conveyor while it was in motion, though he knew it was wrong and in fact made certain that the foreman was not about when he did so. In the other case, a machine operator attempted to replace a transmission belt, though he knew he should not and he knew that there were maintenance men in his factory employed to do that very job. In both cases the injured men recovered 50 per cent. of their damage in the trial court, losing the other half on account of their contributory negligence. In both cases the employers appealed and the damages were reduced by the Court of Appeal, in the former case to one fifth and in the latter case to one tenth. The effect of these judgments as far as the injured men are concerned is that they will get virtually nothing, as the legal aid fund has to be paid back before damages are finally paid out.

These judgments of the Courts of Appeal are illuminating, for until these cases were decided a 50 per cent. award would not have been considered unreasonable in like circumstances. But it seems that the Court is now taking a stronger line, as if to say to such workmen: "You were largely to blame, your employers are admittedly slightly to blame too because they did not provide guards to deter you from your irresponsible actions, but you are not going to benefit by your stupidity." The effect of these decisions should be felt immediately, since the Courts of Appeal decisions are reflected in the Assize Courts of the country. Lawyers should be advising clients similarly circumstanced not to fight actions in which only the legal aid fund can benefit. The Court has apparently hardened its heart. Is it the swing of the pendulum ?

When the British worker could be regarded as a down-trodden, under-paid, under-fed individual the Courts were only too ready to lend a sympathetic ear. They still are to-day but they do so with the knowledge that the British worker (with his union behind him) is not the helpless individual he was, and that usually he works under first-rate conditions. The matter goes further than the individual worker. The House of Lords have recently decided that a trade union can now be sued for breach of contract and damages are recoverable. The effect of this decision would seem to be that employers can now sue trade unions for any damages resulting from an official strike called in breach of, for example, an arbitration agreement.

No Judge is likely to agree, but it does appear that the pendulum has swung, that employers, who have had a very rough passage during the last 50 years, are no longer regarded as necessarily the villains of the piece. The law moves with the times, though some way behind. It tends to favour the underdog, and it will not tolerate the arrogant charlatan, be he the employer of 1900 or the trade union official of 1955. Much remains to be done. Employers are entitled to that cornerstone of British justice—equality before the law—which they will not get until their costs are paid in a winning fight. A firm should not be required to pay just because, as a firm, it is likely to have greater resources than are available to an individual. But if the pendulum has swung, it may be that there will be better discipline in industry, resulting in less accidents and fewer strikes. It is to be hoped that never again will a great organisation like British Railways have to plead rather pathetically (as they did successfully in a recent case) that they had to break a contract because, in effect, the Billingsgate porters told them to do so. The legal aid fund has helped those who were unable to help themselves. It was a just and welcome innovation. In practice it is leading to an equally welcome change: that responsibility must again be carried by the individual. Political and social changes of the past forty years have generally reduced the burden of responsibility carried by the individual, by transferring it to the State or other corporate body. That was not the way to perpetuate democracy.

Weekly Survey

Cover Picture : *The success of the jet engine led many to suppose that the industrial gas turbine would come into common use shortly after the war. This promise was not fulfilled, but now, ten years later, several firms are making substantial progress in this field, and a number of sets are already in service. Our cover picture shows drop-forged compressor-turbine and power-turbine discs being fitted in a gas turbine for a 900 kW turbo-generator set.*

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Engineering in the Van

Engineering continued to play a major part in the record industrial output achieved in October. Provisional figures issued last week by the Central Statistical Office show that last month the index of industrial production was 3½ per cent. higher than in October, 1954, and though in the first ten months of this year the index of total industrial production rose by 4·7 per cent., that of the engineering industry probably increased by about 10 per cent. However, there are some signs that the rate of industrial growth is slackening. During the first quarter of 1955, industrial production stood 6·1 per cent. higher than in the first three months of 1954, but this difference declined to 5·7 per cent. and 3·3 per cent. respectively in the second and third quarters.

There are good reasons for this. First, it must be remembered, when comparing the latest figures with the third quarter of last year, that the end of 1954 was characterised by a big increase in demand for the products of the metal using industries, and this undoubtedly aided a sharp upswing early this year in orders for capital goods, e.g., machine tools and new plant—an upswing which had gathered impetus from the 1954 Budget re-equipment allowance. During the year it has become apparent that producers of capital goods could not hope to meet these demands unless somehow the shortage of labour and materials was circumvented. In fact, competition for labour has led to all round wage increases—from the capital goods industries as they attracted some labour away from producers of consumer goods, and in the latter as labour became correspondingly scarce. The shortage of materials was reflected throughout the year in the necessity to import three times as much steel as in the same period of 1954. Hire purchase restrictions, the credit squeeze and the autumn budget have accentuated the trend on the side of demand, and sales of such things as domestic appliances are running about 20 per cent. lower than at the same period as last year.

By last month it had become apparent that the present phase of the industrial boom is undoubtedly tied up with the prospects for the engineering industry, and with the export side of the engineering industry in particular. If the exports of this industry can continue to make progress while production keeps in step with sales, thanks to a slight increase in productivity (and possibly even a slight increase in the labour force), the boom may well continue for some time. In due course, if the Government's deflationary policy works out successfully so that a nice balance is achieved in the various kinds of capital investment which the country is undertaking at the moment (so that prosperity is sustained without either a severe inflationary or deflationary situation developing), the boom may carry on indefinitely. As the year draws towards an end, however, industrial prosperity is critically exposed to the chill winds of competition in export markets.

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Aluminium in Short Supply

Many industries in the northern hemisphere have suffered during the recent summer from a shortage of water. None has felt the drought more acutely than aluminium. In Scotland the rainfall was so slight as seriously to embarrass the British Aluminium Company's works at Kyle of Lochalsh. The output of virgin aluminium in the first half of this year was somewhat lower than in the corresponding period of 1954, and in July and August the average monthly output was 32 per cent. down.

Most of this country's aluminium ingot comes from Canada, but there too a serious water shortage has appeared. Customers in the United States have been told that their supplies of Canadian metal will have to be reduced owing to the shortage of water power in the Saguenay Valley. Throughout the northern hemisphere (Norway is also affected) this curb on production is taking place at a time when the demand for aluminium is particularly strong. Whether Western Europe, and the United Kingdom in particular, will be seriously affected by the power shortage in Canada now depends to a considerable extent on the ability of the United States aluminium industry to step up its own production and so reduce its need of Canadian ingot. If United States domestic production does not increase, the large and growing appetite of American industry for aluminium may have serious repercussions on Canadian supplies for Western Europe. The Anaconda Copper Mining Company has new capacity which came into production last August at Columbia Falls and is now building up towards full capacity. Over the border in Canada, there are important expansion programmes in hand, including one for the British Aluminium Company, but these will not come into operation in time to help next year.

One favourable feature will be a decision by the United States Government, announced recently, that it will not stockpile aluminium in the first half of 1956 and will not call up its requirements for the last quarter of 1955 before next April. This would provide some relief but it might be only enough to meet the growing demands of United States industry. The problem still remains of finding sufficient aluminium for Western Europe when its own supplies have already been temporarily reduced.

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Machines on the Farm

The Annual Machinery Show at Earl's Court serves once again to focus attention on the increasing mechanisation in the agricultural industry. It is estimated that the British farmer spends over £50 million each year on new equipment and an equal sum on running and operating costs. The high price of a decreasing labour force, rising costs of production, and an attempt to obtain even greater efficiency continues to stimulate the demand for this growing range of more complex machinery.

The agricultural tractor has developed considerably in recent years. Perhaps the most notable feature has been the almost universal change-over to the Diesel engine. Most tractors now offered by manufacturers are so powered, and they serve to replace machines driven by the more inefficient vapourising-oil engine. Hydraulics, too, play an ever increasing part in machine operation, and the tractor in addition to providing motive power serves to supply high-pressure oil services to a number of other units. Many attachments can be fastened on to the tractor, so that it may now be regarded as a mobile power unit, rather than a draught machine to replace the horse.

Other machines and implements continually alter, and generally design and construction improve as each subsequent model is placed on the market. Agricultural engineering has moved out of the realm of the blacksmith, and the great bulk of equipment is now produced by large companies operating efficient factory processes. No longer are heavy steel sections welded and bolted together to form some crude framework; rough-cast gears and open chain drives are fast disappearing, and ease of maintenance and reliability become more important salient features. Cleanliness of design and simplicity should always be aimed at. Welded tubular frameworks and the use of light alloys are replacing the heavy sections and iron castings which have been traditional features, while machine-cut gears and V-belt drives provide smoothness of operation previously notable by its absence. There is an increasing use too, of sealed and self-lubricating bearings to minimise daily servicing, and the old ring-lubricated bearings have been discarded with other equally inefficient components.

Present day engineering knowledge could well improve even the best machines as they exist, but in agriculture economic factors play perhaps an even more important part than in other industries. Cost becomes a dominating factor and the retail price of any new implement must always be balanced by the potential demand for it and its economic application on the farm. Many expensive machines operate perhaps only for two hundred hours annually, and the eternal compromise must be achieved between better and more reliable designs on the one hand, and the potential return which the farmer might obtain by its use on the other.

There is no doubt that good engineering principles can continue to contribute to this industry. Earl's Court again presents a bewildering spectacle of glittering machinery, but all such equipment must eventually operate in the stark reality of farming conditions: not all of it will do so without breakdown, modification and continual nursing, and in many spheres the challenge still remains at the feet of the engineer-designer.

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Iron Castings Output

Output of iron castings continued to increase during the third quarter of 1955—but, as in other fields of industry, at a declining rate. In the first half of the year, production stood at 6·5 per cent. above the corresponding 1954 period, but in the third quarter it was 3·5 per cent. higher than last year's total. The greatest increase was in the supply of castings to the motor-vehicle industry, where total output over the first nine months of the year amounted to about 400,000 tons—a rise of 23 per cent. on the corresponding period of 1954. Production of ingot moulds for the steel industry also increased by a substantial amount, but the down-turn in domestic appliance sales, particularly gas stoves and heaters, has resulted in a decline in output from foundries concentrating on these types of products. Output of building and domestic castings during the third quarter of 1955 was down by 1·5 per cent. on the comparable period of 1954. In this field, output may decline still further as the effect of hire purchase restrictions becomes increasingly felt.

It is unfortunate that foundries in some localities manufacturing castings for motor vehicles are experiencing difficulty in obtaining sufficient low and medium-grade phosphorus iron, for demand is assured. However, the position may become easier early next year when several new furnaces should by then be in full operation and supplies of imported ore may become more plentiful. There were 4,533 more people at work in the industry on October 1, 1955, than at the same time in 1954—an increase of 3·1 per cent. This is a move in the right direction and the industry was able to get a somewhat larger proportionate increase in production from them—a useful if not spectacular increase in productivity thus being recorded.

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Australia takes a Chance

A recent report from Australia on the expansion in manufacturing industry over the six months ended October, 1955, shows that there has been further progress in industrialisation. Some of the basic industries have been developed, and it would appear that part of this programme, at least, is to carry on. As in this country, there is some conflict between the need to encourage investment and the necessity to control inflation. So far as Australia is concerned, the argument in

favour of developing basic industries is essentially a long-term one since it is hoped that industrialisation will reduce dependence on imports. Towards the end of the six months under review, the Australian Government reimposed severe import cuts and the banks were advised not to advance money for capital development or for holding stocks. This was clearly a short-term measure to offset the balance of payments difficulties which have been building up for Australia in the last year. The Dominion is trying very hard to reconcile the long-term desire to industrialise Australia further with the short-term need to reduce investment.

This is a most complicated programme to carry out. In the foreseeable future the prosperity of Australia must be bound up with its great export industries, wool and meat. It is difficult to see how any programme of industrialisation, with occasional jerks at the rein to prevent run-away inflation developing, can overcome this basic reliance on agriculture. A 10 per cent. movement in the world price of wool could do more to improve or worsen Australia's economic position than several years of industrial development. There is always the possibility that the policy which now seems to be evolving will be successful, but it will require a great deal of good fortune and good administration to develop Australia's basic industries as quickly as many in the Dominion would wish them to be expanded, without worsening the balance of payments situation or making costs of production rise steeply. This last possibility would seem to be most unwelcome since Australia cherishes plans to export larger quantities of industrial goods. The British engineering industry, however, will wish Australia well in its chosen policy, for the more rapidly Australia can develop the bigger the opportunities for the export of capital goods from this country.

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Independent Air Operators' Dilemma

With the international airline services monopolised in this country by the two public corporations, it must always be a problem for the independent operators to know how far to develop their activities in collaboration with the corporations and how far in spite of them. The exasperating position in which they find themselves, by having to develop their services in air transportation fields which the public corporations choose to leave alone for one reason and another, comes out in the latest annual report of the British Independent Air Transport Association. In this report for the year 1954-55 the chairman, Mr. M. H. Curtis, points out how difficult it is for the association's members to plan ahead when they are confined to insecure and economically doubtful operations. He emphasises the limited number of new aircraft on order by the 17 operator members of the association. In June, 1955, their combined fleets were 227 aircraft, and only 19 new machines were on order. The independent operator has in fact been too long under the double handicap of having to assess the break-even point of both obsolescent and new aircraft on work which was inevitably fluctuating and insecure. Even when estimates have been completed there have been difficulties in getting enough finance to buy new types. These problems have played a part in the present structure of the independent air operating industry. Some of the most successful of them have collected a remarkably diverse group of activities in an effort to achieve at least a measure of security, while the shortage of finance has made the marriages between such operators and big shipping companies that much more attractive to the former.

Much enterprise has been shown by these companies and some of their projects, such as the car-ferry service to the Continent and the North Atlantic freight service, have been planned and carried out with a very big risk element. These kinds of developments have come about when the only security, such as it is, for many of them has been diversification over a large number of small activities and trooping contracts. The fact is that the air transport industry in this country is woefully out of balance if the Government's announcement in 1952, to increase the opportunities for private enterprise in air transport development, had any real meaning. In a cage, the big animals will trample upon the small ones either intentionally or because the others are too small to be noticed. Only a clear-headed keeper with a strong sense of discipline can make them all live together. The Government, having chosen to put such widely differing examples in the same cage, must take on the job of keeper and carry out its duties effectively. Independent operators have a right to know not only that they are going to stay alive but have reasonable prospects for the future.

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Competition from the French

Industrial conditions in France perpetually baffle the Anglo-Saxon mind. Just as in French politics, economic conditions seem to consist of a series of inflationary crises relieved by periodical brilliant *tours de force* accomplished by the Government of the hour and the permanent officials. In consequence, French competition in overseas markets has for many years been much less of a bogey than German competition. It is true that French competition throughout the world appears much less ruthless, organised and successful than its German counterpart, but its faintly Gaelic insouciance should not lead British manufacturers to underestimate it.

In a recent pamphlet on economic conditions in France, put out by O.E.E.C. in Paris, the general improvement in the French economic situation in the past 18 months is emphasised. Production has expanded notably, foreign exchange reserves have increased and prices have been kept stable. The success over these months has been gained under very favourable circumstances. The demand for French exports has been strong and France enjoyed an excellent harvest in 1954. The balance of payments situation was helped by a heavy inflow of dollars from the United States, mostly for military expenditure. This last factor is already a spent force and France is obliged to close the gap by increasing exports. This emphasises the weakness of France's external position, which is the comparatively high prices of French goods. It not only discourages exports but encourages imports. The need to increase capital investment is apparent in the Second Modernisation Plan which provides for reforms in agriculture, basic and secondary industries. The French Government is prepared to plan boldly, as was seen in the modernisation plan for the iron and steel industry which was mentioned in ENGINEERING of September 16. An intensification of French competition in export markets is therefore likely. How successful it may be must depend on the extent to which prices can be reduced.

In the recent past French companies have often been able to get their prices down—with some startling results to such well established competitors as Germany and the United Kingdom. Indeed, the recent strides which have been made by the French aircraft industry and the impressive number of civil engineering contracts abroad which French engineers have been able to secure, show the potential intensity of competition from that country. If France should be able not only to reduce its export prices but keep them down, the recent advances in French technology should ensure that its challenge abroad will become an increasing factor in the export markets of Western Europe.

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Penny Plain, Twopence Coloured

What is progress? Can we say that we have progressed because we now have the possibility of transmitting colour programmes on the television service, whether or no the content of those programmes is better or worse than the content of our present monochrome service? From the engineer's point of view we must answer yes to the second question. If we, or the B.B.C., in our name, have been able to develop a system of transmitting an adequate reproduction of a coloured scene which can be viewed by the owner of a colour television receiver, they have undoubtedly advanced from the stage when they could only transmit a monochrome programme.

It is, however, interesting to compare this development with the introduction of coloured film programmes to the monochrome film circuits. There is, of course, something to be gained from seeing the scene of the action in glorious Boobicolor but unless the colour is really effective we are tempted to ask whether they might not have saved their money on the colour and engaged a better leading actor. The point, really, is whether in the televising of human affairs the addition of colour adds anything at all to the human-affecting content of the programme. If the answer is yes, then we should develop colour programmes with all available resources. If we are not sure, then we must improve our programmes before we begin to think of giving them the rather bogus boost of colour.

Whatever may be said regarding the use of colour in television programmes, there is no doubt that the British technicians have produced a remarkable adaptation of the American N.T.S.C. system to British needs (page 780). Both American and British engineers are to be congratulated on the problems they have overcome towards the technical realisation of colour television programmes.

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Vote of Confidence

Not only was the success of the British Nuclear Energy Conference's first meeting an indication of engineering interest in the development of atomic power, but it served too as a vote of confidence in the United Kingdom nuclear programme. This faith was confirmed by the speakers from industry who took part in the discussion that followed the reading of the first two papers (see page 804 of this issue). Sir Christopher Hinton, in his opening address, had said that by 1975 nuclear engineering would involve business in the home market amounting to some £300 million a year; and, subsequently, in his contribution to the discussion, Mr. J. Eccles, Deputy Chairman (O) of the Central Electricity Authority, had forecast, on the basis of the second paper, that twenty 200 MW nuclear power stations would be required by 1965, a further eleven by 1970, thirty-five more by 1975, and a further forty-nine by 1980. Thus, by 1980 it would be necessary to have a total of 115 nuclear power stations in operation.

Industry clearly took this as a challenge, confirming that the Government would be right to plan on this basis though it might mean a doubling of the £300 million figure, and expressing its determination to meet the demands that would be involved. Industry could and must cope with the nuclear power programme, said Sir Claude Gibb, chairman of the Nuclear Power Plant Company, speaking in the discussion, and he found it encouraging that the authors of the second paper envisaged a rate of growth far greater than that proposed in the White Paper.

In addition, he believed that the gas-cooled graphite-moderated reactor would not be made obsolete by enriched-fuel reactors and that the United Kingdom policy would be proved correct, giving Britain a substantial lead. This kind of reactor was, however, only competitive with coal for large outputs and might therefore be unsuitable for export purposes in the near future. But they were ideal for Britain's immediate needs. Other speakers referred to the increase in shift working and the need to design large steam turbines capable of satisfactory operation under shift-working conditions. Longevity was also an important factor in design; the failure of a part made inaccessible by radiation would present a serious problem.

TELEVISION IN COLOUR

EXPERIMENTAL EQUIPMENT FOR THE B.B.C.

Colour television has for some years been a practical possibility, and in a simple form it was first demonstrated by Baird in 1927. The experiments at present being conducted by the B.B.C. are designed to find out what system is technically and economically the most suitable to give a colour television service to the public in this country. The aims are to produce a picture that can be received in the home on equipment that is reasonable in cost and size, gives adequate fidelity of colour reproduction, and is reliable in operation over prolonged periods without complex adjustments; to adopt a system that is economical in the band width used; and to consider carefully the claims of the several millions who already own black and white receivers. The latter are interested in a compatible colour television system: that is, one in which an existing monochrome receiver can without modification reproduce a black and white picture from the same transmission as will produce a colour picture on a suitable receiver. A system is non-compatible if an existing receiver cannot reproduce a black and white picture from such a transmission.

PRODUCTION OF COLOURED IMAGES

A coloured light can be completely defined by its hue, purity, and luminance. The hue of a coloured light is determined by its dominant wavelength, which corresponds to the spectrum colours red, orange, yellow, etc. Its purity is the extent to which that dominant wavelength colour has been diluted with white light. The luminance is a measure of the radiated energy of the light; the greater the luminance the brighter the light appears to be.

Colour images are produced either by the subtractive or additive method. The subtractive method is concerned with reflected light. White light is a combination of all colours of light, and a red surface is one which absorbs all the colours radiated by a white light except the red part. The red light is reflected from the surface to the eye and the surface is seen to be red. The second method of colour image formation is the additive method, where the outputs of different light sources are added together to give various colours. Television tubes produce their own light, and it is this method which is of interest in an understanding of colour television.

It was established by Sir Isaac Newton that nearly all colours could be simulated by a mixture of three colours only, and for the additive method these colours were red, green, and blue. He also showed that it was immaterial whether the colours were added simultaneously or sequentially, provided that in the latter case the rate of succession was sufficiently rapid. The information that must be transmitted for a satisfactory colour television service comprises therefore the brightness of the whole picture and either separate pictures in each of the three primary colours, or such information as will enable the three colours to be derived.

Several systems have been evolved to transmit the required amount of information, and they fall into two main types, the sequential and the simultaneous. The sequential requires that three reproductions of every picture shall be made, and to produce a received picture without flicker; this means that on an interlaced system the frame frequency rate must be at least 150 frames per second. The Columbia Broadcasting System in the U.S.A. produced a system on these lines, using rotating filters in front of both camera and viewing tube. The system is non-compatible, and to obtain a coloured picture a normal set would need very considerable modification.

Simultaneous systems send all the information on the three colours at the same time. One method of doing this is for the camera to split the colour information from the picture into the three primary colours, and for the three sets of information to be transmitted at the same time, received on three tubes, and the final coloured image produced from an optical combination of the images on the three tubes. This system uses three times the normal bandwidth, and produces a signal that cannot be received by existing types of receiver.

It was necessary to use three tubes and an optical combination of images before tri-colour tubes were developed. The two best known tri-colour tubes are the Lawrence tube and that made by the Radio Corporation of America, known as the R.C.A. tube. Both of these tubes were described in a paper entitled "The Application of Colour to Television Broadcasting," read by Mr. F. C. McLean* before Section G of the British Association at Liverpool on September 4, 1953. The paper, which forms an excellent and authoritative introduction to colour television, was published in full in ENGINEERING for October 2, 1953 (vol. 176, page 441). The R.C.A. tube, which can rightly be described as a masterpiece of mechanical precision and electronic accuracy, combines the red, green and blue images to give a picture closely approximating to the original picture in colour.

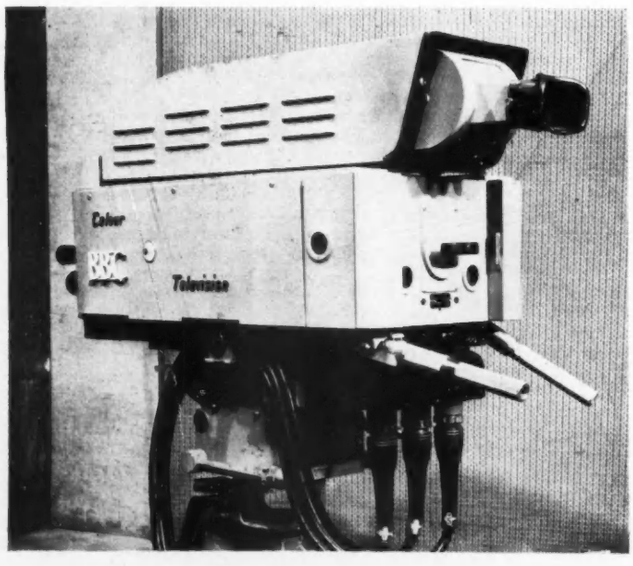

Fig. 2 The camera supplied by Marconi's for the B.B.C.'s colour television experiments. This illustration, taken from the back of the camera, shows the viewfinder, the manipulating handles, and the three cables carrying signals from the three colour tubes.

THE N.T.S.C. SYSTEM

The system of colour television known as the N.T.S.C. system,† is that which is being used in the United States and is the first to be investigated by the B.B.C. It must be stressed, however, that there is no reason to suppose that this system will be adopted by the B.B.C. Experimental work is being done for the Television Advisory Committee, who, in due course, will be able to advise the Postmaster General. The N.T.S.C. system is discussed at greater length than any others because it is the system on which most information is available now.

The N.T.S.C. system pre-supposes the use of a tri-colour tube and specifies that the bandwidth occupied shall be no greater than that for monochrome television; it also specifies that the system shall be compatible with existing monochrome television. These aims are achieved by transmitting three signals: a luminance or brightness component, Y', and a chrominance or colour component having two separate parts, I' and Q'. The luminance component is the same as that which would be produced by a panchromatic monochrome television camera looking at the same scene, and this signal therefore produces a normal monochrome representation of the coloured scene on a monochrome receiver.

The chrominance component consists of two colour-difference signals which, in the simplest terms, may be said to convey the hue and purity of the colour information. In the colour receiver, these three signals representing brightness, hue and purity are combined to produce the required intensity from each of the red, green and blue colours. The fact that a monochrome receiver and a colour receiver can simultaneously produce each its own version of the scene from the same signal gives the N.T.S.C. system its compatibility.

It would be possible to transmit the chrominance signal quite independently of the luminance signal and in this case the compatibility would be virtually perfect. However, in the N.T.S.C. signal the two components have been combined

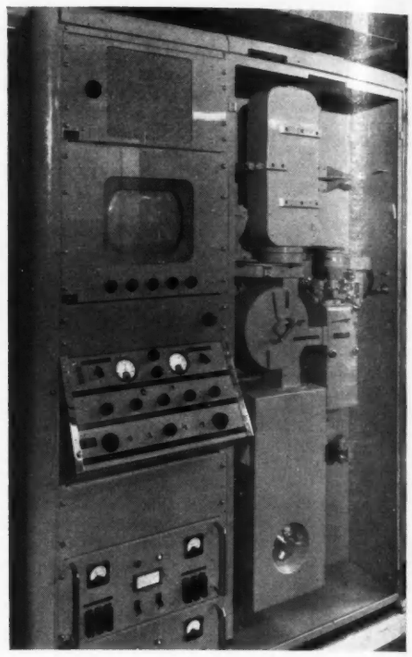

Fig. 1 The colour slide and film scanner used by the B.B.C. in their experiments. It can produce signals for the reproduction of an image either from slides or 16 mm. film. On the left is the power supply cubicle which contains a monochrome picture monitor.

* Deputy Chief Engineer, British Broadcasting Corporation.

† In December, 1953, the Federal Communications Commission approved for public service in the U.S.A. the colour television standards recommended by the National Television Systems Committee (N.T.S.C.).

in such a way that they occupy the same total bandwidth as that used by the equivalent monochrome signal. Because the human eye is more sensitive to brightness than to colour, the separation of luminance and chrominance enables the bandwidth of the chrominance signal to be reduced to about one-third of that of the luminance. Further saving of bandwidth is achieved by placing this reduced bandwidth information at the upper end of the luminance band in such a way that the inevitable interference (cross-talk) between the two signals has a minimum effect on the compatible picture on the monochrome receiver. The actual mechanism by which this band sharing takes place employs a colour sub-carrier (in the British version 2·66 Mc) which is simultaneously modulated in amplitude and phase by the two colour difference signals. The carrier itself is suppressed so that the chrominance signal exists only when colour is present in the scene being transmitted. The colour sub-carrier is an odd multiple of half the line scanning frequency, and in these circumstances the visibility of the beat pattern produced between it and the scanning lines is a minimum.

The experiments at present being conducted by the B.B.C. at Alexandra Palace—which were briefly reported in ENGINEERING for November 4, 1955 (vol. 180, page 631)—are based on the N.T.S.C. system with certain modifications to bring it into line with the British monochrome transmissions. The main objects of the experiments are (1) to explore the degree of compatibility of the system by making observations on some thousands of monochrome receivers, and (2) to see whether the system produces a consistently good quality colour picture.

The present tests will provide a statistical answer to (1) in due course, but it will not be possible to answer (2) reliably until there are sufficient colour receivers available. The test transmissions take place outside normal programme hours and have no entertainment value. They are in no sense a public service and the B.B.C. state that they have no definite plans for the introduction of such a service.

EXPERIMENTAL EQUIPMENT : COLOUR SLIDE AND FILM SCANNER

The equipment in use at Alexandra Palace consists of five main items: a colour slide and film scanner, designed and made by the Research Department of the B.B.C.'s Engineering Division; and a colour camera, signal coding equipment, colour picture monitors and colour test equipment, all made by Marconi's Wireless Telegraph Company, Limited, Chelmsford.

The colour slide and film scanner, shown in Fig. 1, is the source of the pictures which are being transmitted for the present series of tests of the compatibility of the N.T.S.C. signal. It produces pictures from slides either 3¼ in. by 2½ in. or 2 in. by 2 in. or from 16 mm. film, by selection of the appropriate optical system.

The scanner employs the flying spot principle and the source of light is a cathode ray tube of which the phosphor emits light as evenly as can be achieved over the whole of the visible spectrum. The light from the raster on the face of the scanning tube is passed either through the slide or the film as desired and the coloured image so produced is then split into three separate parts, which represent respectively the red, green and blue information in the picture. This colour analysis process is performed by a combination of dichroic mirrors, colour filters, plane mirrors and lenses. The three colour separation pictures, which emerge from the analyser as three physically separate rays of light, are then focused each on to a photo-multiplier tube which turns the intensity of the light, which is varying in accordance with the scene being scanned, into corresponding electric voltages. The three voltages are then passed through three separate and identical chains of electronic equipment which supply gamma correction, correction for the distortion introduced by the finite decay time of the light from the scanning tube phosphor, and equalisation for aperture loss, exactly as in the case of a monochrome flying spot scanner.

The film transport mechanism is a standard intermittent motion 16 mm. projector with a "pull-down" time of about 4 milliseconds. Since the time available for "pull-down" is only 1·4 milliseconds, if all the lines of the television picture are to contain information, some picture information is inevitably lost. This loss occurs at the top and bottom of the picture where about 15 lines are presented as black. In order to preserve the usual aspect ratio of 4 : 3 an equivalent area at the sides of the picture is also black. The picture therefore appears as in a black frame, but this disadvantage is accepted because the arrangement permits of a simple and efficient optical system. Synchronism between the film motion and the television picture repetition rate is achieved in a simple way by supplying power to the synchronous motor of the film transport mechanism by amplifying the 50 cycles per second component of the frame pulses.

At the bottom right of the right-hand cubicle in Fig. 1 is a large rectangular box containing the scanning tube. The recessed three-spoked handle moves the scanning tube physically for focusing the image. The optical system contained in the drum above the scanning tube deflects the light from the raster either into the slide holder immediately above or into the film scanning mechanism at the right. Above the drum is a rectangular box on pivots, which contains the colour analysing filters and the three photo-multiplier tubes. It is shown in the slide scanning position: for film it is swung over to the right so that it accepts light emerging from the film scanner through the funnel-shaped outlet above the transport mechanism. The rack on the left contains power supplies, a control panel and a monochrome picture monitor. A further cubicle (not shown) contains the electronic equipment associated with the red, green and blue separation signals.

THE COLOUR CAMERA

Coloured light entering the lens of the camera is split into three colour separation images by a colour analyser similar in principle to that used in the slide and film scanner. In place of the three photo-multiplier cells are three 3 in. image orthicon camera tubes of a type developed specifically for colour work. These tubes produce the three colour separation signals in electrical form. Each of the tubes is supplied with the necessary scanning waveforms and electrode potentials just as in the case of the single-tube monochrome camera. The output of each tube is a separate picture of which not only the transfer-characteristic between light input and voltage output must be maintained in a precise manner for the three signals, but the geometry of the three pictures must be the same within very close limits so that any particular detail of the picture occurs at the same point in the scanning cycle of all three.

The signals from the tubes are amplified in the camera and transmitted to the control room over three identical cables. In the control room each signal is gamma corrected and equalised in a manner very similar to that used in monochrome equipments employing the same type of camera tube, and finally emerges as a colour separation signal of the same form as that produced by the slide and film scanner. Fig. 2 shows the camera from the back, with the viewfinder, manipulating handles and cables carrying the signals from the three tubes.

SIGNAL CODING EQUIPMENT

The signal coding equipment includes the special colour waveform generating equipment and the encoder in which the luminance and chrominance signals are formed from the incoming three colour information. The master frequency, from which all the other scanning and pulse waveforms are derived, is obtained from a temperature controlled crystal oscillator the frequency of which is 2·6578125 Mc per second accurate to ± 8 cycles per sec. This frequency is multiplied and divided to produce the usual double line frequency of 20,250 cycles per second, from which the standard 405 line interlaced waveform is generated.

The input to the encoder consists of the three gamma corrected colour separation signals (red, green and blue) which are produced by either the slide and film scanner or by the camera. The encoder may be considered as performing a single linear transformation of the three incoming signals, red, green and blue, to the other three quantities, Y′, I′ and Q′, of which Y′ is the luminance signal. The colour sub-carrier is then modulated by the I′ and Q′ signals in such a way that the amplitude of the resultant signal conveys the purity information and the phase conveys the hue. In the absence of colour information the sub-carrier is suppressed. The complete chrominance signal is added to the

Fig. 3 A general view of the colour studio control room. On the left is the film scanner, in the centre back the three-tube colour picture monitor. In the centre front is the control console, which clearly shows the three control panels for the three colours. To the right is the power supply and pulse generation equipment, and on the extreme right the colour receiver with the R.C.A. tri-colour tube.

luminance which is, of course, in video form. Finally, the synchronising waveform is added to produce the complete waveform. The synchronising waveform is of the normal type except that a " burst" of nine cycles of the colour sub-carrier is added in the suppression period following every line synchronising pulse. This " burst " is used at the receiver to synchronise a sub-carrier generator needed for detection of the quadrature modulated chrominance signal.

In the general view of the colour studio control room shown in Fig. 3 the waveform generator and the encoder are mounted in the two cubicles adjacent to the camera control equipment in the centre.

MONITORS AND TEST EQUIPMENT

There are two colour picture monitors. One employs three separate tubes, the phosphors of which emit respectively red, blue and green light. The application of the colour separation signals to the grids of these tubes produces three colour separation images which are combined optically by dichroic mirrors to produce a direct viewed colour picture. This method brings with it the attendant difficulty of superimposing the three separate images accurately, just as in the colour cameras. However, up to the present, this method produces the best pictures and its complication is worth while in a monitor intended for technical purposes. This monitor is seen in the centre of the control room in Fig. 3. The other monitor uses the 15 in. R.C.A. shadow-mask tri-colour tube referred to above and can be seen on the extreme right of Fig. 3.

The complicated nature of the N.T.S.C. signal requires special test signals and measuring apparatus to ensure that its specification is met. The main signal for this purpose, " colour bars," is generated electronically and produces on the picture monitor seven vertical strips which, from left to right, are white, yellow, cyan (blue-green), green, magenta (purple), red and blue. These signals represent saturated colours for which the amplitude and phase of the colour sub-carrier are known. The amplitude is measured in the usual way with a waveform monitor; the phase is measured by a special piece of test equipment known as a colour signal analyser. Distortion occurring in the transmission of the signal after it has left the encoder can be measured similarly.

Other electronically generated signals such as " dots " and a grid pattern of lines covering the whole picture are provided for the purpose of adjusting the picture monitors. The camera and slide and film scanner have a series of special test cards for the alignment of the apparatus.

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INSTITUTE OF METALS

Nuclear Energy Committee

The Council of the Institute of Metals have appointed a Nuclear Energy Committee with the object of stimulating interest in metallurgical problems arising in connection with the industrial and scientific uses of nuclear energy.

The committee hopes to arrange an exhibition of nuclear-energy products, of interest to metallurgists, in connection with the Institute's spring meeting in April, 1956.

The members of the committee comprise: Mr. G. L. Bailey (British Non-Ferrous Metals Research Association); Mr. E. W. Colbeck (Hadfields Limited); Dr. Maurice Cook (Imperial Chemical Industries Limited, Metals Division); Dr. S. F. Dorey (Lloyd's Register of Shipping); Dr. H. M. Finniston (U.K. Atomic Energy Authority); Dr. Ivor Jenkins (General Electric Company, Limited); Professor A. G. Quarrell (the University of Sheffield); Mr. L. Rotherham (U.K. Atomic Energy Authority); Mr. S. S. Smith (Imperial Chemical Industries Limited, Metals Division); and Major P. L. Teed (Vickers-Armstrongs (Aircraft), Limited).

Persons interested should communicate with the secretary of the Institute of Metals, 4 Grosvenor-gardens, London, S.W.1.

Obituary

MAJOR K. GORDON, C.B.E., M.C.

A Distinguished Chemical Engineer

We regret to record the sudden death, which occurred in London on Tuesday, November 29, at the age of 58, of Major K. Gordon. As a young man he had a successful military career and was thereafter engaged on the design of synthetic oil plant and with the development of the applications of atomic energy.

Kenneth Gordon was born on April 18, 1897, and was educated at Merchant Taylors' School. He joined the Army in 1915 and served for the remainder of the 1914-18 war with the East Surrey Regiment and the Machine Gun Corps, attaining the rank of major and being awarded the Military Cross. On the conclusion of hostilities he went to St. John's College, Oxford, and obtained a first class in the Honours School of Natural Science in 1921.

After acting for about a year as university lecturer he joined the Synthetic Ammonia and Nitrates Division of Imperial Chemical Industries, Limited, at Billingham, and in 1927 was appointed research manager at their works. He became a member of the board in 1931 and was appointed joint managing director five years later. He was one of the designers of the hydrogenation plant erected at Billingham in 1933 and in 1940 was also partly responsible for the plant constructed at Heysham to produce aviation petrol. In 1942 he became vice-chairman of the Diffusion Committee of Tube Alloys, a body that was concerned with the applications of atomic energy; and in 1946-47 was responsible for the design of petroleum chemical plant both at Wilton and Billingham.

In 1948 he joined Trinidad Leaseholds, Limited, as technical director, becoming managing director a year later. He was appointed deputy managing director of Head Wrightson Processes, Limited, in 1951, but twelve months afterwards became Director-General of Ordnance Factories on the retirement of Sir Charles McLaren. He was occupying this position at the time of his death.

Major Gordon was appointed a Commander of the Order of the British Empire in 1944. He was the author of several papers on coal and oil hydrogenation and other subjects.

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MR. F. H. ROGERS

Chemical Engineer and Patent Agent

We note with regret the death of Mr. Francis Heron Rogers, which occurred in a West Croydon hospital on November 27. He was senior partner in the firm of Heron Rogers and Randall, consulting industrial and chemical engineers, 181 Queen Victoria-street, London, E.C.4. Mr. Rogers was born in Birmingham on November 11, 1877, and was educated at the Grocers' Company's School in London. In 1893, at the age of 16, he was apprenticed to F. M. Rogers and received training in the workshops and drawing office in London and Dundee. While in London, he was able to attend technical courses at the City and Guilds College, Finsbury.

In 1899, when only 22 years of age, Mr. Rogers passed the Board of Trade qualifying examination and became a patent agent. Soon afterwards he began to practise that profession and also took up consulting work in various branches of engineering. In 1913 he was joined as partner by Mr. F. B. Dehn, who remained with him until 1919, and in 1915 by Mr. W. R. Pettit, who remained in the firm for a number of years during which it was known as Heron Rogers and Pettit. Subsequently Mr. D. G. Randall became a partner in the firm.

Mr. Rogers and his partners have been responsible for the design and erection of many factory installations of a very varied character, including plants for producing drawn filaments of tungsten and molybdenum, fine chemicals and drugs, inorganic pigments and organic dyestuffs, explosives, compressed gases, and various vegetable and mineral-oil products.

As first honorary treasurer of the Chemical Engineering Group of the Society of Chemical Industry, Mr. Rogers worked with vigour and enthusiasm to help found the Institution of Chemical Engineers, which was established in 1922. For the first six years of its existence he was honorary treasurer of the Institution, after which he served as a vice-President and finally was elected President in 1939. He was made an associate member of the Institution of Mechanical Engineers in 1912 and transferred to the class of member in 1918.

Mr. Rogers was a director of Stream-Line Filters, Limited, the British Vacuum Cleaner and Engineering Company, Limited, the Oliver Typewriter Manufacturing Company, Limited, and other companies.

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LT. COL. G. T. BENNETT, O.B.E.

Engineering and Road Safety

We have learnt with regret of the death of Lieutenant-Colonel G. T. Bennett, a leading highway engineer who had often pleaded the cause of road safety and the contribution that could be made to it by the proper planning of road layout. At the time of his death, which occurred on Monday, November 28, he was county surveyor of Buckinghamshire, a post he took up in 1948 after holding similar office in Oxfordshire since 1927, except for the war years, 1939 to 1945, when he served with the Royal Engineers in the Middle East and later in France, Belgium and Germany.

Graham Townsend Bennett was born on October 30, 1895, and received his education at the Merchant Venturers' School, Bristol, and later at the University there. His university career was interrupted by the first World War, when he was commissioned in the Worcester Regiment, and he completed his studies at Bristol in 1919. He then served a two-year studentship under Mr. A. P. I. Cotterell, a consulting engineer specialising in waterworks and sewage-disposal works. On completion of his training he continued as a resident engineer for Mr. Cotterell before making his first entry into municipal engineering in 1921, as an assistant to the City Engineer, Oxford, later being appointed County Surveyor of Oxfordshire in 1929.

Colonel Bennett was a past-President of both the County Surveyors' Society and of the Institution of Highway Engineers. His presidential address to the latter Institution in 1947 described the successful alterations that had been made to road junctions in Oxfordshire so that, over a period of seven years, the fatal accident rate had been cut by 76 per cent. In welcoming the formation of the National Road Research Board, he appealed for a greater recognition of the fact that defective roads were often the cause of accidents. Colonel Bennett was elected an associate member of the Institution of Civil Engineers in 1922 and was transferred to the class of full member in 1945; he had been a member of council since November, 1951, until a month before his death, but due to failing health had asked that his name should not be put forward for re-election to the council.

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We regret also to record the deaths of :

MR. ROBERT LOCKHART HAMILTON, in hospital at Edinburgh on November 18. He was managing director of the National Steel Foundry (1914) Ltd., Kirkland Works, Leven, Fife. He joined the company in 1916 and had been its managing director for 18 years.

MR. ARTHUR RUSSELL, on November 22, at the age of 66. Mr. Russell who was technical director of Goodwin Barsby & Co. Ltd., makers of road, quarry, gravel and contractors' plant, St. Margarets Ironworks, Leicester, had served the company for upwards of 50 years. He commenced as a boy in the drawing office and rose to the position of technical director in 1948. He retired from the board a short time ago owing to ill health. His services, however, had been retained in an advisory capacity.

Letters to the Editor

SCIENTIFIC METHODS IN THE ARMY

Development of Armaments

SIR, In the first paragraph of your interesting leading article "War in Peace" (page 521, October 14) you refer to the Army Council as having "no background of scientific training" and state that "with the possible exception of a former sapper officer, none of the men who direct Army policy has had the kind of experience which is vital to a technically equipped force."

I would point out that the dissemination of scientific advice to the members of the Army Council and the directors of the War Office is the responsibility of the Scientific Adviser to the Army Council who, generally, is an eminent scientist in the academic field. This policy of bringing scientific methods to the problems which face the Army is implemented at each level. In the War Office the Scientific Adviser is assisted by a number of scientists who advise at the departmental staff level. Still within his jurisdiction is an outstation and operational research sections attached to overseas theatres, whose object is to study the scientific trends in, and implications of, new equipments, different methods of training and trial techniques.

You have in the third paragraph rightly contrasted armaments with vehicles and electronics. Armaments is the difficult case where user knowledge is largely confined to the services and where there is no large-scale civilian industry on which the whole system of procurement can be based. You are also right in suggesting that the system whereby user experience is fed back to the designer is by no means perfect. But you suggest that there is no system; this is quite untrue and in the next few paragraphs I explain what the system is.

In the Army, the essential link between the user and the designer is the technical staff officer. The majority are recruited from the user arms, particularly Royal Armoured Corps, infantry and gunners. After about ten years regimental service they come to the Royal Military College of Science for a 2½ years course. During the first year they study mathematics and science and engineering—officers with suitable degrees are excused this. During the last part of the course students study the applications of science and engineering to the three main divisions of weapons, fighting vehicles and fire direction. The last covers the rapidly growing field of electronics and servo-mechanisms. Each student studies in two of these three divisions, and in addition all do a course in atomics and guided weapons. The culmination of the course is a design exercise where students working in teams first write a user requirement (say of a new weapon) based on tactical needs and then do a design study up to the stage of a wood mock-up.

Technical staff officers leave the College well equipped for their subsequent work. In the first five to ten years after taking the course they alternate between technical staff appointments and regimental duty. Technical staff appointments may be in the War Office, at War Office schools, or on the headquarters staffs of field formations; the majority, however, are in the Ministry of Supply, where T.S.O.'s are used as inspecting officers, as members of research and design teams, at trials establishments and at headquarters. The technical staff officer is (intended to be) the link between the user on one hand and the scientist and engineer on the other, and his training and career are well planned to enable him to do this work. The scheme is not a new one; the first course was started in 1864.

You mention that "the technical officer's job is the maintenance of equipment," but it should be stressed here that there is little connection between the work of the technical staff and the work of the Royal Electrical and Mechanical Engineers. The emphasis on the technical staff course is on future developments and the effects of these on tactics, whereas the emphasis of R.E.M.E. is on repair and maintenance. There is, however, some interchange between the two as a few R.E.M.E. officers take the technical staff course. In addition to the technical staff, we now have a short course designed for Staff College students. The majority of them come here for three months to learn something of the problem of equipment procurement and of the contribution that science can make to solve the soldier's problems.

The Royal Military College of Science is situated at Shrivenham, near Swindon, and the Commandant and Staff of the College are always ready to welcome visitors to show them the training that is being carried out there.

Yours faithfully,
C. L. RICHARDSON,
Major-General, Commandant.

Royal Military College of Science.
November 28, 1955.

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PUBLIC TECHNICAL LIBRARIES

Cost Set Against Use

SIR, A Weekly Survey note in your issue of October 28 asks for information on the use made of technical libraries and the cost of providing the service. In Glasgow we have a very extensive technical reference library, which is administered as a part of the Mitchell Library (which is a general reference library) and there is no separate financing and accounting for this section of the service. It is possible, however, to give a reasonably accurate estimate of the cost of maintaining this technical collection and I offer you the following figures for the technical collection of the Mitchell Library:—

	£
Books, periodicals, binding ..	3,450
Administration	10,090
Heating, lighting, cleaning, repairs, etc.	3,730
	£17,270

Total issues, 1954-55 = 116,713.

A separate commercial library is maintained by the Glasgow Corporation Public Libraries and this department also includes a patents library (British, American, Colonial and Eire) and a collection of upwards of 4,000 trade catalogues.

Maintenance figures for this commercial library are :—

	£
Books, periodicals, binding ..	2,750
Administration	3,222
Rent, heating, lighting, cleaning, etc., ...	3,227
	£9,199

Yours faithfully,
A. B. PATERSON,
City Librarian.

The Mitchell Library,
Glasgow, C.3.
November 30, 1955.

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ULTIMATE STRENGTH OF THICK-WALLED CYLINDERS

SIR, I have read with much interest Mr. Jorgensen's letter in your issue of October 28 (page 591). I agree with much of what he says, but I think he exaggerates the difficulty of not having "available a stress strain curve of the very material going into his cylinder." The test-to-test variations in high-class materials of the same specification are usually very small, and in my experience the stress-strain records vary still less. I am surprised that he has to contend with "variations in properties up to 10 to 15 per cent.," and I am quite sure that the products of British steel manufacturers are considerably more consistent than that.

If one accepts as a reasonable philosphy that thick-walled cylinders may be designed against an ultimate bursting pressure, and that for any given material this quantity is dependent only on the ratio of outside to inside diameters, then all that is required is a curve relating these two variables. Our theory enables this to be prepared as the logical development of a characteristic test of the material, e.g., torsion. It is certainly possible to obtain very close approximations to it by various empirical formulae involving such properties as the ultimate tensile strength, and there is no reason why one of these should not be used, provided its reliability has been proved. The extent to which empiricism of this sort is permissible with less well known materials is, however, a matter upon which the individual designer has to satisfy himself.

In my view it is desirable to support the theoretical curve, however derived, with one or two actual bursting tests, but these are by no means easy experiments to carry out; the ultimate bursting pressure, being defined as that pressure which will *eventually* cause failure if maintained for long enough, can by the nature of things only be determined accurately if the pressure is raised very slowly and ample time is allowed for the strains to reach equilibrium.

I believe that one advantage of the more elaborate theory is that it can be—and preferably should be—derived from a torsion test, where the type of loading approximates much more closely to that in the walls of a cylinder. Moreover, I do not believe that the arithmetic involved is too elaborate or complex for practical use, and, in my expeience, anyone reasonably conversant with the procedure can work out a case in six to eight hours. Incidentally, it is also possible to use a tensile stress-strain curve as the starting point, but this may introduce some uncertainty if little is known about the properties of the material. One then has to decide first of all what is the criterion of overstrain and plastic flow; the fact that the hypothesis usually called after von Mises appears to fit the behaviour of most of the common engineering materials is no guarantee that it will suffice for everything.

Yours faithfully,
W. R. D. MANNING.

Red Cottage,
Townsend-avenue,
St. Albans.
December 5, 1955.

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DEVELOPING A DESIGN

Value of Statistical Methods not Recognised

SIR, Your excellent editorial "Developing a Design" (November 25 issue) will probably make little or no impression upon the great majority of engineers. Most of them have had no training in the philosophical appraisement of statistical methods, but are heavily conditioned to the acceptance of empirical judgments in many fields where statistical analysis might be better.

I indulged in a spare-time one-man campaign of three papers on these matters some years ago. I tried to show, for instance, that the Central Electricity Board specification for the mechanical tests of line insulators was mathematically ridiculous (*Jl. I.E.E.*, vol. 83, 1938); that factors of safety might be mathematically assessed (*Jl. I.E.E.*, vol. 87, 1940); and that there was some very fancy and quite inapplicable mathematics in the currently applied methods of quality control in machine shop work (*Proc. I.Mech.E.*, vol. 154, 1946).

My campaign can safely be said to have left not the slightest suspicion of a ripple on the surface of engineering affairs. I wish better luck to Dr. Morris in the adoption of his theory for reducing the cost of prototype development, and to you; but don't expect anyone to know what you are talking about!

Yours faithfully,
W. O'DEA.

5, Heathcroft,
London, W.5.
December 1, 1955.

PERSONAL

SIR CYRIL HINSHELWOOD, M.A., D.Sc., F.R.S., Dr. Lee's Professor of Chemistry in the University of Oxford since 1937 and Fellow of Exeter College, Oxford, has been elected President of the Royal Society. He has been foreign secretary of the Society from 1950 and previously served on the Council from 1933 to 1934 and 1949 to 1950. DR. H. G. THORNTON, F.R.S., head of the department of soil microbiology at Rothamsted Experimental Station, has been elected foreign secretary in succession to Sir Cyril.

MR. W. D. PUGH, Assoc. Met. (Sheffield), F.I.M., F.I.I.A., F.R.S.A., has relinquished the office of managing director of the Darlington Forge Ltd., and has been appointed deputy chairman. Dr. C. J. DADSWELL, M.I.Mech.E., F.R.S.A., has been appointed a director and MR. W. S. SCOTT, M.A., managing director of the company. MR. W. E. A. REDFEARN has been appointed assistant managing director of English Steel Forge and Engineering Corporation Ltd. The above appointments took effect on December 1.

DR. D. M. TOMBS, M.Sc., A.C.G.I., D.I.C., A.M.I.E.E., until recently senior lecturer in telecommunications at the Imperial College of Science and Technology, London, has been appointed to take charge of a newly-constituted research department of Hoover Ltd., Perivale, Greenford, Middlesex.

SIR HENRY SPURRIER, M.I.Mech.E., M.I.P.E., M.Inst.T., managing director of Leyland Motors Ltd., Leyland, Lancashire, has been elected President of the Motor Industry Research Association.

MR. JOSEPH JONES, M.I.Mech.E., managing director of the National Gas and Oil Engine Co. Ltd., Ashton-under-Lyne, has been appointed deputy chairman of the company from January 1, 1956. He will then relinquish his present position and be available to all the companies in the Brush Group Ltd. in a consultative capacity. They will thus have the benefit of his engineering knowledge and experience. MR. S. WEBSTER, at present deputy managing director, will be appointed managing director of the National Gas and Oil Engine Co. from January 1, 1956.

PROFESSOR R. J. CORNISH, of the department of municipal engineering, College of Technology, Manchester, has been appointed by the Royal Society of Health, to be its representative on the building advisory committee of the Royal Technical College, Salford.

MR. J. C. M. SUTCLIFFE, senior engineer and ship surveyor in the South and South-West of England district office of the Marine Survey Service of the Ministry of Transport and Civil Aviation, has been appointed principal officer of the Northern Ireland district, Belfast, with effect from December 18, in succession to MR. J. W. THOMPSON, M.I.N.A., who is retiring.

MR. L. F. KLAUSEN, principal surveyor to Lloyd's Register of Shipping for Denmark and secretary to the Danish Committee, is to retire at the end of the present year when he will have reached pensionable age, His successor will be MR. W. D. LYDERSEN, B.Sc., a senior ship surveyor at Copenhagen.

MR. R. W. EVANS, T.D., M.Met., F.I.M., formerly melting shops superintendent, Steel Co. of Wales Ltd., Abbey Works, Port Talbot, has been appointed assistant general manager (operations). MR. I. S. SCOTT-MAXWELL, M.I.Mech.E., A.M.I.E.E., who until now has held the position of chief engineer, is to be assistant general manager (engineering and development).

MR. ARTHUR WALKER has been made managing director of Henry Berry & Co. Ltd., hydraulic engineers, Leeds. MR. D. COLEY has joined the board and now holds the appointment of chief engineer.

MR. J. E. P. DUNNING, M.A., A.M.I.Mech.E., A.F.R.Ae.S., has been appointed chief superintendent, Rocket Propulsion Department, Royal Aircraft Establishment, with effect from December 1, in succession to DR. T. P. HUGHES, M.A.

The North of Scotland Hydro-Electric Board, Edinburgh, have made two new appointments to fill the vacancy of chief hydraulic and civil engineer previously held by MR. A. A. FULTON, now general manager of the Board. MR. L. H. DICKERSON, M.I.C.E., A.M.I.W.E., has been appointed chief civil engineer and MR. P. L. AITKEN, B.Sc., A.M.I.C.E., chief hydraulic engineer.

MR. G. M. PALMER is joining Vauxhall Motors Ltd., Luton, Bedfordshire, as an assistant chief engineer. He will concentrate his attention primarily on passenger-car development.

MR. G. R. BLAKELY, B.Sc. (Eng.), M.I.C.E., M.I.Mech.E., M.I.Prod.E., who joined G. A. Harvey & Co. (London) Ltd., Greenwich Metal Works, London, S.E.7, in 1952 as general works manager, has been elected to the board as works director.

MR. R. V. BRADSHAW, M.I.Mech.E., A.M.I.E.E., has been elected to the board of M. & B. Plastics Ltd. He joined the May & Baker group of companies Dagenham, Essex, in 1932.

MR. W. B. NODDINGS, M.Eng., M.I.E.E., a deputy commercial manager, Central Electricity Authority, Winsley-street, London, W.1, has been appointed head of the commercial department of the Authority, in succession to MR. E. R. WILKINSON, M.I.E.E., M.I.Mech.E., who as announced on page 486 of our issue of October 7, 1955, is relinquishing his post on December 31 to join the boards of Power Securities Corporation Ltd., and Balfour Beatty & Co. Ltd. MR. R. L. KAY, A.M.I.Mech.E., A.M.I.E.E., senior assistant and deputy to the steam testing engineer of the North Eastern Division of the Authority, has been appointed steam testing engineer of the Division in succession to MR. P. G. LLOYD, who has retired.

Electric and Musical Industries, Ltd., Hayes, Middlesex announce that MR. KENNETH MOORE has been appointed manager of the trade division of E.M.I. Suppliers Ltd., in succession to MR. N. LEGASSICKE, who has left the company to take up an appointment in the United States. Mr. M. H. Moss has been made assistant manager of the division.

MR. R. D. LEE, B.E.M., has joined the British Central Electrical Co., Ltd., 6 and 8 Rosebery-avenue, London, E.C.1, as manager of their sales and plant departments.

MR. H. C. HOWARD has been appointed service engineer to John C. Beadle (Coachbuilders) Ltd., Dartford, Kent.

MR. G. F. SHRIGLEY has been appointed director of production, Rootes Group Manufacturing Division, and will serve on the boards of the various manufacturing companies. Accordingly, he will relinquish his present position as general manager, British Light Steel Pressings Ltd. MR. R. HALL, until recently general manager, Nuffield Metal Products Ltd., is succeeding Mr. Shrigley as director and general manager, British Light Steel Pressings Ltd.

MR. J. P. FORD has been appointed managing director of Charles Colston Ltd., 3 Mill-street, London, W.1.

MR. P. F. HANCOCK, research manager, Birlec Ltd., Tyburn-road, Erdington, Birmingham, 24 MR. A. E. PICKLES, manager, induction heating division, and MR. J. F. ROSS, works manager, have been appointed directors of the company.

MR. F. H. GARDNER has joined the sales staff of Martonair Ltd., Parkshot, Richmond, Surrey, as technical representative for the West of England. MR. C. P. WHITE has taken up a similar appointment in the North East and MR. R. J. TAYLOR has left the technical department at the head office in Richmond to cover south London.

MR. E. BRADFORD BARTON, 51 Albert-road, Grappenhall, near Warrington, Lancashire, has taken over the northern area representation for the foundry division of Sheepbridge Equipment Ltd. MR. C. J. CALORI has been appointed sales manager to Hardinge Machine Tools Ltd., another company in the Sheepbridge Engineering Group, Chesterfield.

DR. W. C. DAVEY, manager of the chemical research division at the Dunlop Rubber Co.'s research centre, Birmingham, has been appointed manager of the compounding research division, in addition to his present duties.

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COMMERCIAL

A new separate David Brown self-contained industrial-tractor division has been formed, as from December 1. All home and export sales inquiries should now be addressed to DAVID BROWN TRACTORS (ENGINEERING) LTD., Hanworth Park, Feltham, Middlesex (Telephone: Feltham 5271; telegrams: "Industrac" Feltham). A service and spares depot is also being established in the North, at Moll Springs Mills, Netherton, near Huddersfield. (Telephone: Honley 460). The manager of the industrial-tractor division is MR. R. W. LADBROOKE; MR. S. HALLAM becomes superintendent of the new depot at Netherton, MR. L. PATTISON is superintendent, home sales; MR. L. K. HUNTER, superintendent, export sales; and MR. J. V. HARVEY, superintendent, spares department. The three last-named will operate from Feltham.

As from December 1, THE VACUUM OIL CO. LTD., Caxton House, Westminster, London, S.W.1, changed their name to MOBIL OIL CO. LTD. There has been no change in the ownership, management or policy of the company.

THE HELI-COIL division of ARMSTRONG PATENTS CO. LTD., have appointed the MODERN TOOL AND EQUIPMENT CO. LTD., 7, 9 and 11 East Bridge-street, Cromac Square, Belfast, to be their stockists for Northern Ireland.

THE BROCKWORTH ENGINEERING CO., a member of the HAWKER SIDDELEY GROUP and "home" of the Armstrong Siddeley Sapphire jet engines, is now to be known as ARMSTRONG SIDDELEY (BROCKWORTH) LTD. The change is one in name only.

THE BRITISH THOMSON-HOUSTON CO., LTD., Rugby, have formed a new company, the BRITISH THOMSON-HOUSTON CO. CENTRAL AFRICA (PRIVATE) LTD., with offices in Salisbury, Bulawayo and N'dola. MR. K. C. FORD, B.Sc., A.M.I.E.E., has been appointed general manager; also on the board is MR. G. R. A. JOHNSON of JOHNSON & FLETCHER. MR. H. GORDON MCHAFFIE, B.Sc., A.M.I.E.E., has been made director and general manager of the newly-established BRITISH THOMSON-HOUSTON CO. (CANADA) LTD., with headquarters in Toronto. The company also has a branch office in Montreal.

HEAD WRIGHTSON PROCESSES LTD., Teesdale House, 24-26 Baltic-street, London, E.C.1, manufacturers of mechanical cooling towers for many years, now offer a complete inspection, maintenance and repair service for water-cooling towers of all makes and models.

SIR GEORGE GODFREY AND PARTNERS LTD., Hampton-road, Hanworth, Middlesex, have arranged with SVENSKA ROTOR MASKINER, STOCKHOLM, an exclusive licence to manufacture the S.R.M. high-speed rotary screw-type compressor and expander for aircraft use. This arrangement extends the firm's existing range of cabin superchargers and cooling units.

DAVEY, PAXMAN & CO., LTD., Standard Ironworks, Colchester, have effected changes in their London office to provide additional facilities to the oil industry. MR. W. K. BURLEY, oil-field sales representative, has been transferred to the London office at 1 Balfour-place, Mount-street, London, W.1. (Telephone: GROsvenor 6114 or 2486.) The firm's associate company, RUSTON & HORNSBY LTD., Lincoln, have appointed MR. F. KING to represent them in a similar capacity at the same address.

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CONTRACTS

Steam Turbo-Alternator Set. The Nova Scotia Light and Power Co. have placed a second order with the ENGLISH ELECTRIC CO. LTD., Marconi House, Strand, London, W.C.2, for a 45,000 kW 3,600 r.p.m. steam turbo-alternator set, complete with feed-heating and condensing plant, for installation at their Water-street power station, Halifax, Nova Scotia. The value of the order is approximately £450,000. The first set was ordered in July, 1954. The second set, like the first, will be built at the company's Rugby Works. The turbine is designed to operate with steam at 900 lb. per square inch gauge at 900 deg. F., at the turbine stop valve. The alternator is of the hydrogen-cooled type for generation at 13,200 volts, three-phase, 60 cycles.

Overhead Line for Trolley-bus System. A contract placed by John Pook & Co. Ltd., on behalf of the Colombo Municipality, Ceylon, is for the supply and erection of overhead-line equipment for a 2¼ mile extension to the City's trolley-bus system. The contract has been awarded to BRITISH INSULATED CALLENDER'S CABLES LTD., and will consist of grooved cadmium-copper conductor on bracket arms or span wires and includes turn-outs, junctions and turning circles. The system will operate at 550 volts direct current and will be fed through paper-insulated lead-sheathed steel-tape armoured and served cables with shaped conductors.

Textile Mill. A contract for the design and construction of a new textile mill in Kaduna, Nigeria, has been awarded to TAYLOR WOODROW (WEST AFRICA) LTD., by David Whitehead and Sons, Ltd., Rawtenstall, Lancashire, managing agent for the recently-formed Kaduna Textiles Ltd., sponsored by the Northern Regional Development Board of the Government of Northern Nigeria. The mill, which will produce cloth from locally-grown cotton, incorporates a tubular steel Arcon frame, 650 ft. long and 225 ft. wide, to be supplied by the associated company, TAYLOR WOODROW (BUILDING EXPORTS) LTD. The mill is scheduled to be finished in 12 months.

Book Reviews

SCIENCE ENLIVENED BY ART

An Illustrated History of Science. By F. SHERWOOD TAYLOR. *William Heinemann, 99 Great Russell-street, London, W.C.*1. (25*s.*)

Engineering fathers, with the call to turn their sons and daughters into the paths of scientific learning ringing in their ears, and with the perennial Christmas gift problem almost on top of them, can now kill two birds with one stone. This reprint of the traditional Christmas lectures given in 1952 by the Director of the Science Museum before a juvenile auditory at the Royal Institution, is the ideal gift for an intelligent boy or girl between the ages of eleven and eighteen and could be read with advantage by many adults, not excepting some with claims to specialist knowledge in one or other of the fields of science or technology.

The original lectures were based on some historical experiments of natural science which were demonstrated in a fashion as near as possible to that of their originators. Realising that they would lose much of their force if a dry description were substituted for a living demonstration, Dr. Taylor asked Mr. A. R. Thomson, R.A., to undertake a series of realistic illustrations which greatly enliven the straightforward text of the six chapters of the book. The result is a hundred and twenty charming, lively and frequently amusing illustrations which do much to destroy the often held illusion that science is austere and scientists inhuman. To counter in advance those severe critics who will point out that there is no authority for much of the details in the illustrations, an appendix is provided indicating some of the sources used by author and artist in presenting these visual pictures of the men and events which have brought science to its present position of pre-eminence.

The four middle lectures deal with the 300 years before the beginning of this century, during which the foundations of modern experimental science were laid and, towards the end of the period, the material harvest began to be garnered. Attention is focussed on the enormous gap that separated the ancient natural philosophers (whose use of brilliant logic based on their imaginations in describing the nature of matter is the subject of the first chapter, and who treated almost with contempt those who, working with their hands, conducted experiments) from the astronomers, anatomists and artists who began to trust their eyes and to devise experiments to test their hypotheses.

The physical sciences receive far more attention than the biological; no doubt because of their amazing development both in knowledge and application over the last 200 years. The development of man's understanding of the nature of matter and of energy must to-day play a dominating part in a history of science, although the character of the research work done in this century makes its illustration to a youthful audience a difficult task. All that Dr. Taylor can do is to illustrate the extraordinary contrast between the simple laboratories of the earlier scientists and the heavy machinery of the modern physicist investigating the smallest parts of which everything in the universe seems to be composed. It is this investigation "down to the foundations" which he claims best expresses the scientific work of the Twentieth Century. In this work the boundary between chemistry and physics has been replaced by the common ground of the study of atoms and molecules and the forces that influence them. While atomic physics is now the centre of the growth and activity of science, biology is creeping up on it as the boundary between it and chemistry becomes the centre of intense activity. But we are still very ignorant of the nature of the material of which living beings are made.

So much knowledge and power have come into men's heads and hands that they are ceasing to think of science as some specialised occupation, but as a way of understanding and organising any job of work. Yet, as Dr. Taylor points out, science knows little and may never know much of the human mind and so it can do little for the artist, the leader of men and the man of religion. This may be true, but might not a keen-minded boy or girl, comparing the fantastic acceleration of knowledge in the physical sciences that has taken place during a tiny fraction of man's history with the aeons of darkness which preceded it, feel the urge to participate in what may be the start of a similar period of advance not only in the understanding of the nature of living organisms, but also of the mental processes by which the highest forms are mainly actuated ?

Dry Dust Suppression and Percussive Drilling. Information Bulletin No. 55/144. *National Coal Board, Hobart House, Grosvenor-place, London, S.W.*1. (Gratis to approved inquirers.)

There are cases where it is undesirable or impracticable to use the standard method of dust suppression—the application of water through the drill "steel." The National Coal Board's Central Research Establishment has carried out tests on three methods of catching the dust and drillings at the hole, and five units for collecting the spoil and suppressing the dust. Some of these items are interchangeable. The dust catching methods are the Belgian hood, the Hemborn suction head and the Holman Dryductor. The Belgian hood consists of a helical tube through which the drill rod passes, a flexible rubber cowl, and a rubber suction hose connected to the suction and disposal unit. The Hemborn suction unit is a sleeve fitting over the specially-shaped shank end of the drill rod, which is hollow. A suction hose attached to the sleeve draws the dust away from the hole. The Holman Dryductor also has a hollow drill rod, and cuttings are drawn through it from the hole, but in this case they pass through the centre of the machine to the suction hose.

Of the five suction heads tested one is designed for use with the Belgian hood, one is for the Hemborn unit, and one is for the Dryductor; the remaining two can be used with either the Belgian hood or the Dryductor. The Clark eductor, which operates with the Belgian hood, is the only one studied which uses water for dealing with the dust drawn from the hole. It has two ejectors, fed by compressed air; one draws the dust from the hole and the other draws water from a canister to damp the dust, which is deposited on the ground as a sludge. The Hemborn suction unit operates with compressed air which is expanded through a nozzle to produce a negative pressure in the body of the unit. A suction current is thus induced in the drill or drills (one or two may be used with each unit). The nozzle is surrounded by three fabric filter bags. Provision is made for dealing with water which may be drawn in from the strata being drilled, to prevent clogging of the filter cloths. The dust is deposited in a detachable container. A unit which is somewhat similar in operation to the Hemborn is the Huwood-Holman dust collector. This also has a compressed-air jet and a bag filter. Dust is collected in a detachable canister which is provided with a lid for use when the dust is being taken away for disposal. This unit can be used with either the Belgian hood or the Dryductor.

Fabric filters are also the basis of the Vokes dust trap, in which there are two cylindrical filters. The dust-laden stream first passes through a chamber in which the heavier particles are deposited by cyclonic action. A compressed-air eductor provides the suction, and the dust falls into a paper bag which can be sealed and taken away for disposal. The Holman unit operates on a somewhat different principle. It has a suction current induced by a compressed-air eductor, and the dust-laden stream is drawn through three cyclones and a bag filter, which deal with progressively finer material. The cyclone canisters and filter bag can all be removed for emptying.

The tests showed that the Belgian hood has a lower performance than either of the other two dust-catching methods used. It is also less convenient to use. Both the Hemborn and the Holman systems were equally as effective as the application of water. The disposal of the collected dust and debris is an additional operation compared with wet drilling, but the experiments showed that safe and economic procedures can be evolved. Bit wear was found to be much less with dry drilling than with wet drilling. Using steel bits it was discovered that the dry bits still had two-thirds of their life to go before resharpening, when the wet bits were ready for discarding.

THE LANGUAGE OF DRAWING

General Mechanical Drawing. By WILLIAM JERVIS. *International Textbook Company, Scranton, Pennsylvania, U.S.A.* (3.20 dols.); and *Macmillan and Company, Limited, St. Martin's-street, London, W.C.*2. (21*s.*)

Elementary drawing and constructive activities like paper folding are common practice at the kindergarten school stage. The logical sequel—education and practice in drawing things—not as "Art" but as a normal language and means of expression and description, is not so usual at later stages, although an ability to sketch and draw things is of the highest value to anybody, whether this ability is used professionally or not. As the author states in a foreword, to be worthy of a place in the curriculum, mechanical drawing must do more than train skills which may be used later in a vocational way.

This book, based on ten years experience in an American high school, is an attempt to fill this gap, dealing with teaching mechanical drawing not so much as a subject in of itself, but as the language in which ideas, methods, and constructions can be expressed and, in doing so, helping the development of the ideas themselves. It develops a course covering engineering, architectural, topographical and other allied mechanical drawing work in a commonsense manner which should stimulate the interest of the pupil throughout. The ground covered includes: scale of drawings, styles of lettering, floor plans, maps or topographic drawings, including use of survey data and contour lines, graphs and pictorial charts, related views of orthographic projection, working drawings, assembly drawings, pictorial drawings (isometric projections and elementary perspective), developments of surfaces of solids, and geometry in mechanical drawing. Each chapter is well provided with exercises and supplementary questions for further development of the ground covered.

When dealing with a wide range in a small book, some of the ground is inevitably rather thinly covered, e.g., there are no proofs of geometrical constructions, though these, and the essential linking up of geometry, algebra and arithmetic, are probably best dealt with elsewhere. To what extent the work covered could be included in a school curriculum without crowding out something of equal, or even greater, value it is difficult to say, but the book is to be commended in its attempt to bring the universal language (drawing) into the school curriculum in a form where it is likely to survive in after years. Minor changes in idiom and examples would be needed in British schools, but anyone engaged in teaching drawing other than as "Art" would find this book interesting and probably useful.

BOOKS RECEIVED

Some of the books noticed here are selected for extended review in ENGINEERING.

Britannica Book of the Year, 1955. *Encyclopaedia Britannica, Britannica House,* 102 *Dean-street, London, W.*1. (84*s.*)

A considerable part of the 1955 Britannica Book of the Year is devoted to subjects of engineering interest, and the contents include sections dealing with the following: atomic energy, docks and harbours, plastics, industrial health, civil aviation and aircraft construction, electricity and electronics, trade unions, machinery and machine tools, canals and inland waterways, railways, jet propulsion and gas turbines, building and construction work, bridges, wages and hours, town and country planning, the European Coal and Steel Community, petroleum, statistics, international funds and banking, the Colombo Plan, iron and steel, metallurgy, rubber, water supply, oceanography, telecommunications and radio, physics, roads and motor transport, tunnels, patents, munitions, shipping, and light and heavy engineering. Among the contributors are Professor J. F. Baker, head of the Department of Engineering, Cambridge University (on bridges); Dr. W. H. Glanville, Director of Road Research, D.S.I.R. (on roads) and Professor J. A. S. Ritson, Professor Emeritus of Mining, University of London (on coal). The volume is amply illustrated and well indexed.

Accidents which Occurred on the Railways of Great Britain during the Year 1954. Report to the Minister of Transport and Civil Aviation. *H.M. Stationery Office, Kingsway, London, W.C.*2. (2*s.* 6*d.*)

This is the report of the Chief Inspector of Railways to the Minister of Transport and Civil Aviation on the accidents which occurred on British Railways during 1954. These accidents are grouped under the headings of train accidents, movement accidents, and non-movement accidents. Casualties in each of the three classes are further sub-divided into passengers, railway servants and other persons. Summaries of the inquiries into all three classes are included as well as a considerable amount of statistical information.

Principles of Technical Electricity. By M. NELKON. Second edition. *Blackie and Son, Limited,* 17 *Stanhope-street, Glasgow, C.*4. (10*s.* 6*d.*)

This textbook which was first published in 1946, has been written for students who require a presentation of the fundamental principles of electricity with reference to the technical applications. The standard is that of the City and Guilds Telecommunications examinations, Principles I and II. The text covers the heating, chemical and magnetic effects of current, measurements and instruments, and alternating-current theory and its applications, especially with regard to radio.

Safety Measures in Chemical Laboratories. Second edition. Published for the Department of Scientific and Industrial Research, by *H.M. Stationery Office, Kingsway, London, W.C.*2. (1*s.* 6*d.*)

This booklet was originally prepared in the form of notes for the guidance of new entrants to the Chemical Research Laboratory, and it was published in the hope that it might be of value to a wider public. The information covers general laboratory operations, fire risks, electrical hazards, dermatitis and the dangers of poisons and gases. Where appropriate, methods of treatment are given.

The Electrical Engineer's Reference Book. Edited by E. MOLLOY and M.G. SAY. Eighth edition. *George Newnes, Limited, Tower House, Southampton-street, London, W.C.*2. (70*s.*)

The eighth edition of this well-known reference book has been considerably enlarged. The additions include chapters on "Gas Turbine Power Plants" and "Nuclear Power for Electricity Generation" as well as on "The Mechanism of Arc Extinction," "Metal Rectifiers" and "Rotating Amplifiers." The chapters on the mining industry, transmission and distribution, education and motors have been revised, the latter taking account of the new British Standard 2613-1955. There is a long list of specialist contributors.

Electricity Undertakings of the World, 1955-56. The Electrical Journal Red Book. 65th edition. *Benn Brothers, Limited, Bouverie House,* 154 *Fleet-street, London, E.C.*4. (30*s.*)

The 65th edition of this well-known reference book has been brought up to date by including the changes in organisation which have taken place in electricity supply arrangements both in the United Kingdom and elsewhere. The whole of the statistical matter, covering not only the United Kingdom but the Commonwealth and foreign sections, has been revised and there are a number of additional entries in the overseas section. The section relating to the Service Centres of the Area Boards has been re-arranged in a form which, it is hoped, will facilitate quicker reference to the different localities in which they are situated. The index has been strengthened by including the appropriate consumers' voltages.

Plastics Tooling. By MALCOLM W. RILEY. *Reinhold Publishing Corporation,* 430 *Park-avenue, New York* 22, *N.Y., U.S.A.* (2.50 dols.); and *Chapman and Hall, Limited,* 37 *Essex-street, London, W.C.*2. (20*s.*)

This is one of the "Pilot Book Series" intended as information sources on new techniques in their early stages. It covers the "whys" and "pros and cons" of plastics tooling; the nature of plastics; plastics tooling resins; fabricating the tools; checking, locating and assembly fixtures; metal forming tools; plastics forming tools; die models and prototypes; experimental tools and the future.

Elements of Machine Design. By EMANUEL ROSENTHAL and GEORGE P. BISCHOF. *McGraw-Hill Book Company, Incorporated,* 330 *West* 42*nd-street, New York* 36, *N.Y., U.S.A.* (4.50 dols.); and *McGraw-Hill Publishing Company, Limited,* 95 *Farringdon-street, London, E.C.*4. (34*s.*)

The theory of machine design is presented in a simplified form for use in (American) technical institutes and trade schools. Properties of metals are surveyed and problems in applied mechanics discussed; the main body of the book is devoted to the design of machine parts. The text is based on the "problem approach"—that is, a specific problem is posed, analysed and a solution presented. A number of examples is given at the end of each chapter.

Principles of Electric Utility Engineering. By CHARLES A. POWEL. Published jointly by the *Technology Press of the Massachusetts Institute of Technology,* and *John Wiley and Sons, Incorporated,* 440 *Fourth-avenue, New York* 16, *N.Y., U.S.A.* (6 dols.); and *Chapman and Hall, Limited,* 37 *Essex-street, London, W.C.*2. (48*s.*)

This book is based on lectures given at the Massachusetts Institute of Technology to students returning to that institution after service in armed forces. These lectures were designed to counteract the fallacy that there was little future in electrical engineering outside the field of electronics. The subjects covered are sources of energy; steam and hydro-electric power stations; transmission and distribution of energy; and associated matters. The treatment is general rather than particular.

Aluminium im Ingenieurbau. Prepared by the Aluminium-Zentrale e. V. Düsseldorf. *Aluminium-Verlag G.m.b.H., Düsseldorf, Germany.* (6 D.M.)

This brochure of 90 pages expounds the use of aluminium in structural engineering. Material properties of various aluminium alloys are given, including their behaviour at low temperatures, and examples of calculations are worked out. Recommendations for the dimensioning of structures, for riveting and welding are made. A number of reproductions of photographs of a great variety of structures, either completed or in course of erection, are given.

Die Steuerung des Gaswechsels in schnellaufenden Verbrennungsmotoren: Konstruktion und Berechnung der Steuerelemente. By WOLF-DEITER BENSINGER. Part 16 of Konstruktionsbücher. *Springer-Verlag, Reichpietschufer* 20, *Berlin, W.*35. (12 D.M.)

This monograph deals with the control of the gas change in high-speed internal combustion engines. The author is chief engineer of the Daimler works in Stuttgart-Untertürkheim. It describes, after a discussion of the underlying theoretical principles, valves, springs, cams and their arrangement. Formulae are given for the calculation of the acceleration forces acting on the cams. Derivations of these formulae are not given, and therefore a knowledge of calculus is not required. Sleeve valves and rotary valves are discussed. A table is included which gives the principal dimensions, the moving masses, acceleration and deceleration and the resulting forces of valve controls which have given satisfaction in practice. The book contains 106 illustrations.

Electric Traction Engineering: An Introduction. By E. A. BINNEY. Cleaver-Hume Electrical Series No. 10. *Cleaver-Hume Press, Limited,* 31 *Wright's-lane, Kensington, London, W.*8. (15*s.*) (Reviewed on page 753, in the issue of December 2.)

Electric Railway Engineering. By T. FERGUSON. *Macdonald and Evans, Limited,* 8 *John-street, Bedford-row, London, W.C.*1. (57*s.* 6*d.*) (Reviewed on page 753, in the issue of December 2.)

TRADE PUBLICATIONS

Copies of any of the following trade publications are obtainable from the addresses given, though distribution is sometimes restricted.

Examples of Material Handling. MECHANICAL HANDLING ENGINEERS ASSOCIATION, 94/98 Petty France, London, S.W.1. Third edition of coloured illustrated brochure giving examples of all types of materials handling. Two sections: countryside and factory; and docks and harbours. Items illustrated include conveyors, transporters, telphers and ropeways.

Optical Control of Block Gauges. HILGER AND WATTS LTD., 98 St. Pancras-way, London, N.W.1. Booklet entitled "Use of Light Waves for Controlling the Accuracy of Block Gauges," by Dr. F. H. Rolt, O.B.E., M.I.Mech.E., describes the manufacture, measurement and surface finishing of block gauges using interferometry.

X-ray Diffraction Equipment. HILGER AND WATTS LTD., 98 St. Pancras-way, London, N.W.1. Apparatus for X-ray diffraction investigation made by "Enraf."-N.V. Nederlandsche Röntgen-Apparatenfabriek, Delft, Holland, for whom Hilger and Watts are agents in this country. Illustrated catalogue.

Airport Heating and Snow Melting. A. M. BYERS CO., Pittsburgh, Pennsylvania, U.S.A. "Radiant Heating and Snow Melting for Airport Installations." Technical data issued by company's engineering service department in 32-page illustrated report.

Centrifugal Fans. DAVIDSON & CO., LTD., Belfast, N. Ireland. Centrifugal fans for supplying mechanical draught in steam raising plant. Sirocco series, with straight, inclined and aerofoil blades. Descriptive booklet giving details of construction, drive and inlet control systems. Ref. No. SF299.

Gas-Pressure Controller. GEORGE KENT LTD., Luton, Bedfordshire. Blind-setting gas-pressure controller for any value between — 6 and + 6 in. water gauge. Does not provide either indication or record. Various combinations of control terms available. Leaflet 377/1055.

Engraving Machine. DAVID DOWLING LTD., Roebuck-road, Hainault, Ilford, Essex. Bench engraving machine with pantograph action giving reductions of from $\frac{1}{2}$ to $\frac{1}{8}$. Size of table 16 in. by 20 in. Work area from 15 in. by 10 in. at 1 to 2 reduction to 15 in. by 4 in. at 1 to 8. Leaflet.

Dissolved Oxygen Recorder. CAMBRIDGE INSTRUMENT CO., LTD., 13 Grosvenor-place, London, S.W.1. Apparatus for recording dissolved oxygen in feed water. Two ranges 0 to 0·1 parts per million and 0 to 0·5 parts per million. Leaflet 323 gives full details.

Packaging Development. EXPORT PACKING SERVICES LTD., Imperial Buildings, 56 Kingsway, London, W.C.2. Interim progress report on packaging research and development at company's research station, Sittingbourne. Illustrated brochure.

Glass Silk and Fibre. VERSIL LTD., Rayner Mills, Liversedge, Yorkshire. Versil glass fibre insulation, flexible and rigid. Versil glass silk thermal and acoustic insulation, airfilters, frames and cells. Illustrated descriptive leaflets and price lists.

Hand Pumps. PLENTY & SON, LTD., Eagle Iron Works, Newbury, Berkshire. The Handipump, reversible and self-priming, for viscosity ranges from gasoline to bitumen, at pressures up to 300 lb. per sq. in. Develops 27 in. Hg suction. Illustrated leaflet.

Heavy-Duty Hacksaw. QUALTERS AND SMITH BROS., LTD., Old Foundry, Barnsley. Two-speed 6 in. heavy-duty power hacksaw with relief mechanism on return stroke. Automatic stop at completion of cut. Illustrated leaflet.

Contra-Rotating Fans. DAVIDSON & CO., LTD., Belfast, N. Ireland. Contra-rotating axial-flow fans for mine ventilation: Details of 20 in. fan which handles 7,000 cub. ft. of air a minute at a pressure of 7¼ in. water gauge. Leaflet S.F. 425.

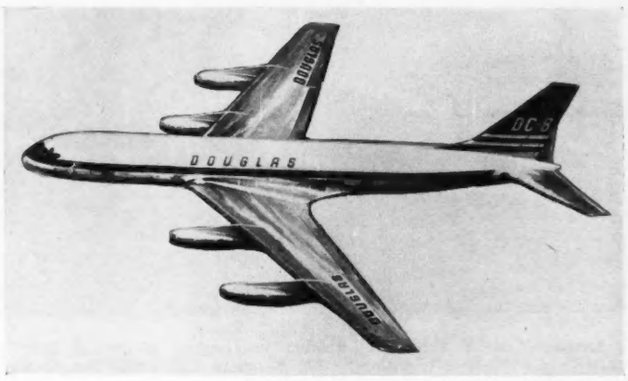
Hydraulic Power Presses. W. H. MARLEY & CO., LTD., 105 High-road, London, N.11. "Marlco" hydraulic presses, eight models ranging from 12 to 50 tons capacity. Electrically driven pump giving three ram speeds. Illustrated leaflet.

Fluorescent Lighting. MORLEY'S ELECTRICAL SERVICES (HOLLOWAY) LTD., 117 Hornsey-road, London, N.7. Tubes, fittings, control gear. Illustrated leaflet.

Dustproof Lighting Fitting. THE BENJAMIN ELECTRIC LTD., Tottenham, London, N.17. Dustproof Flurolier fitting for 80 watt 5 ft. tube. Illustrated leaflet.

Hiduminium Stampings. HIGH DUTY ALLOYS LTD., Slough, Buckinghamshire. Aircraft stampings in Hiduminium. Booklet of illustrations.

The Boeing 707 jet transport prototype during a test flight. A military tanker-transport version is in production for the U.S.A.F. and an airliner development is on order for Pan-American Airways and American Airlines.



An artist's conception of the Douglas DC8 airliner, which is due for delivery early in 1958. The DC8 is on order for Pan-American Airways and United Air Lines.

SOME ASPECTS OF THE AMERICAN AIRCRAFT INDUSTRY

(1) ACTIVITIES OF THE MAJOR CONSTRUCTORS

The opportunity occurred earlier this year to visit aircraft and aero-engine constructors in the United States and Canada. The American aircraft industry is a large one, absorbing some 800,000 employees, and although our visits included several of the principal organisations, we had to omit many firms whose contributions to American aviation are of great importance. These articles then, are not a complete survey of the American aeronautical industries, but, a record of some personal impressions and observations during a brief tour.

The establishments we were able to visit were as follow:—the headquarters of the Convair Division of General Dynamics Corporation at San Diego; the headquarters of North American Aviation Incorporated, the main Burbank works of the Lockheed Aircraft Corporation, and the Santa Monica and El Segundo divisions of the Douglas Aircraft Company, Incorporated, all at Los Angeles; and Boeing Airplane Company at Seattle. These we believe to be the five major aircraft constructors of America, all of which have, in addition to the plants visited, several other establishments in other localities engaged in design, development and construction.

In a rather different category is the Bell Aircraft Corporation at Niagara, New York, which, so far as aircraft are concerned, is primarily a research and development organisation feeling the way for the future, and notable for their very advanced supersonic rocket-powered aircraft and vertical take-off machines; although at their Fort Worth division at Texas—unfortunately outside our itinerary—they rank as one of the two principal producers of helicopters, the other being the Sikorsky division of United Aircraft Corporation at Bridgeport, Connecticut. Bell are also heavily involved in the production of missiles, missile guidance systems and rocket motors.

The three engine firms seen were the Aircraft Gas Turbine Division of the General Electric Company at Cincinnati, Ohio; the headquarters of the Curtiss-Wright Corporation at Woodridge, New Jersey; and the main works of the Pratt & Whitney Aircraft division of United Aircraft Corporation at East Hartford, Connecticut. We saw also their allied company, the Hamilton Standard division of United Aircraft Corporation, at Windsor Locks, Connecticut, still mainly propeller manufacturers but branching out into a range of other products for turbine-powered aircraft and while at San Diego we also paid a short visit to Solar Aircraft Company, principally a sub-contracting firm to the engine manufacturers but also constructors of small auxiliary gas turbines and engaged on the development of heat-resistant materials. The after-burner developed by Solar has recently become the subject of a manufacturing licence agreement with the Bristol Aeroplane Company Limited.

In Canada, we selected two members of the Avro Canada group—Orenda Engines, Limited and Avro Aircraft Limited, both at Malton, Ontario, since these two firms are pursuing the most advanced projects in Canadian aeronautics and have built up the largest design and development organisations. These two young Canadian companies have not yet attained the scale of operations of the American companies; thus, they are concentrating on the needs of the Royal Canadian Air Force in producing the Avro CF100 interceptor and the Orenda engine, which powers both the CF100 and the Canadair-built Sabre 5 and 6 fighters, and in developing a supersonic fighter and the engine to power it. They have not yet embarked on missiles or atomic power.

We do not propose to describe in detail—or even to list—all the aircraft, engines and other products currently being constructed or investigated by the firms we visited, since these cover a very wide range. Dealing first with the civil aeroplanes, Lockheed Super Constellations—including the long-range 1649 due to fly in about a year's time—and Douglas DC6-B, DC7 and DC7-C airliners (and military versions of the former) are in current production, while Convair are producing the 440 development of the Convair Liner, as well as military adaptations for ambulance duties, training, electronic flying test-beds, domestic transport, etc., both for the Navy and the Air Force.

AIRLINERS: JETS OR TURBOPROPS

There is some diversity of opinion among these American designers on the relative merits of the jet and the turbo-propeller power plant for civil aircraft. Convair who, with Canadair Limited, and the Bristol Aeroplane Company Limited, have recently announced their plans for building jointly a 120-passenger aircraft with a range of about 5,500 miles, designed around Bristol BE25 turbo propeller engines, have stated, as a result of considerable experience of turbo-propeller operation in their R3Y Tradewind cargo flying boat and Allison-turbine-powered experimental Convair Liners, that " turboprop aircraft will be more efficient for short- and medium-range distances than turbojet planes." This view is shared by Lockheed, who also have a background of turbo-propeller experience from their C130A cargo aircraft and the military Pratt & Whitney turbine-powered Super Constellation under evaluation by the navy and air force. As is now well known, Lockheed announced earlier this year plans for an advanced and very attractive turbo-propeller airliner, the Electra, for 66–91 passengers with a range from 100 to 3,000 miles at a cruising speed of over 400 m.p.h. Thirty-five of these aircraft have already been ordered by American Airlines and 40 by Eastern Airlines. The prototype is expected to fly in about a year, and deliveries are promised for 1958.

The Boeing company, who have recently been granted permission by the United States Air Force to proceed with a civil airliner version of the 707 jet transport, and who have experience both of large jet aircraft and turbo-propeller operation, concede that the turbo-propeller could be attractive economically but consider that, for trans-oceanic civil operation, its possible advantages are outweighed by its greater mechanical complications. But Douglas—whose projected 80–131-seat 550 m.p.h. DC8 jet airliner, which they have promised for delivery early in 1958, will be in competition with the Boeing 707 development—state categorically that, for aircraft carrying 100 or more passengers, the faster jet-propelled machine is superior over all ranges down to 500 miles. On the other hand, they foresee a useful future for the large turbo-propeller freighter.

With the Comet accidents and investigation still fresh in our memory, we were

The North American Super Sabre F.100C, capable of carrying atomic bombs at supersonic speed, has been delivered to the United States Tactical Air Command.

Supersonic Convair F.102A all-weather interceptors in one of their first formation flights over Southern California.

interested to discover that here American opinion appeared to be fairly unanimous. Whereas in the United Kingdom we have heard some members of the aircraft industry question the wisdom of holding the technical inquiry on the disasters in public, in America it appears to be thought generally that Great Britain has performed a valuable service in publicising the full details of the investigation. At the same time, Lockheed, Douglas and Boeing are not at present prepared to accept the necessity for fatigue testing a complete aircraft by means of repeated pressure cycles and flight loading on the wings.

These companies all adopt a policy of conservatism in civil aircraft design and construction. They believe that their present techniques of repeated-pressure-testing of representative specimens, coupled with the fact that their advances in speed and altitude have taken place gradually with a considerable background of previous operating experience—particularly in the case of Boeing, who have many thousands of hours of experience on B.47 and B.52 and 707 aircraft, all highly pressurised—are an adequate insurance against catastrophe. It remains to be seen whether the Civil Aeronautics Administration concur in the opinion that tank tests are unnecessary; the Administration have not yet formulated their airworthiness requirements for jet airliners.

ADVANCED MILITARY AIRCRAFT AND MISSILES

In the development and production of high-performance military aircraft and guided missiles it cannot be denied that the United States have advanced considerably farther than Great Britain. Convair, Douglas, Lockheed and North American are all constructing a diverse selection of combat aircraft both for the Air Force and the Navy, and all have in production truly supersonic fighters—the North American F.100 swept-wing interceptor being the first level supersonic aircraft to go into squadron service with the United States Air Force. Convair have recently delivered their first production " wasp-waisted " F.102A delta-wing supersonic all-weather fighter to the Air Force, and they have a production order for the B.58 supersonic bomber. The Douglas F4D Skyray supersonic carrier-based interceptor also adopts the delta-wing form. Convair, Douglas and Lockheed are also constructing military cargo aircraft—as are also Boeing—and among the military trainers, mention must be made of the Lockheed T2V1 jet-propelled aircraft for the Navy, the first production aircraft to be equipped with boundary layer control.

The Boeing company are still producing B.47 bombers at their Wichita, Kansas, works (also being built under licence by Lockheed and Douglas), but are tooling up there for production of the B.52 bomber. The KC135 tanker-transport aircraft for the Air Force—the military version of the Boeing 707 jet transport aeroplane which is to serve as a refuelling tanker for the B.52 bomber force—is in production at Boeing's Renton, Washington, plant. The first of the 350,000 lb. B.52 bombers was delivered to the Air Force in July. Interesting points about this machine are its cross-wind landing gear and the fact that the flying controls of this large, fast aircraft are not power-operated.

With the exception of Lockheed, who did not enter the guided missile field until 1954 and are now working on ram jet developments, most of the American aircraft firms visited have been concerned with missile development, or with rockets and ramjets for their propulsion, during the past ten years. Already in service is the Douglas Nike surface-to-air missile powered by a Bell rocket, and Douglas have also in production the Sparrow supersonic air-to-air missile and the Honest John rocket. The Navy's Convair Terrier surface-to-air missile is in production and the Air Force's Bell Rascal air-to-ground missile is under development.

Both Boeing and North American are developing long-range missiles, the latter company's Navaho weapon being intended for surface-to-surface use.

ATOMIC PROJECTS

The comparative progress of atomic power for aircraft in Great Britain and the United States is impossible to assess, since little has been said about such work going on in the United Kingdom, and no detailed information on the state of development in America is available. It is known, however, that nuclear power projects absorb a considerable part of the research and development effort of the major American aircraft firms—not necessarily confined to aircraft applications. North American, for instance, are solely concerned with the development of reactors for research and industry—they have supplied an installation for the University of California at Los Angeles and have constructed a sodium graphite reactor for electrical generation for the Atomic Energy Commission which will be in full operation next year. Convair, who are well advanced on a nuclear aircraft study, also hope to enter the industrial field. Aircraft and missile applications are also the subject of studies by the Boeing, Lockheed, Pratt & Whitney Aircraft, Curtiss Wright and General Electric companies.

TURBOJETS: BRITAIN STILL LEADS

In jet engine development the United Kingdom is still ahead of the United States, although the American engine companies have made good progress in the last few years, and with their comprehensive facilities and staff they may be expected to provide severe competition in this field. The current production engines—the 6,000 lb. thrust General Electric J47 (with after-burner, the J47 develops 7,500 lb. thrust), the " 10,000 lb. plus " thrust Pratt and Whitney J57 (which powers most of the American supersonic fighters now flying), and the 7,800 lb. thrust Curtiss-Wright J65—are all giving excellent service. The latter engine is the American version of the Armstrong Siddeley Sapphire, built under licence, but re-engineered to American production standards and equipped with Curtiss-Wright's own after-burning equipment. The thrust developed with after-burning has not been revealed.

In comparing British and American jet development, it has to be remembered that during the second World War the two big piston-engine manufacturers, Pratt & Whitney Aircraft and the Curtiss-Wright Corporation, were concentrating entirely on piston engine production and played no part in gas-turbine development. Both these companies, as well as the General Electric Company—and also Orenda Engines Limited in Canada—are now working on advanced turbojets for supersonic aircraft.

The Lockheed T2V-1 jet trainer for the U.S. Navy is the first production aircraft to incorporate boundary layer control for improving low-speed handling.

The 350,000 lb. Boeing B.52 Stratofortress bomber is unusual in not having powered controls and in being fitted with cross-wind landing gear.

The Bell helicopter flight simulator, showing the pilot "approaching" for a "landing" on a heliport. The panoramic projection equipment is above the pilot's head.

ELECTRONICS

The "weapon systems concept" which obtains in America places on the prime contractor for an aircraft or missile the responsibility for procuring and co-ordinating virtually all the component systems. This has led to the development of electronics and servo-mechanism engineering within the aircraft companies on a scale far larger than in the United Kingdom although here, too, electronics strength is growing rapidly. In the United States, the aircraft firms' electronics teams are concerned not only with the development of guidance systems for missiles and automatic fire control systems for aircraft, electronic engine controls, etc., but also with radar systems, automatic pilots, flight simulators, computing machines, etc.

The Bell company in particular have expanded their electronics activities, and their Niagara Falls plant has been converted solely to the production of such components. Much of this work is devoted to missile control systems and is highly secret. Among their "mentionable" developments is a completely automatic carrier landing system for bringing naval aircraft safely on deck in bad weather. This comprises radar equipment which locates the aircraft, determines its altitude and position in relation to the carrier deck, and computes speed and direction. These figures are fed to an electronic computer which determines the necessary course corrections which are then transmitted by radio to an automatic flight control system in the aircraft. Should the aircraft not be in the best position for landing, the equipment directs the aircraft round again for another attempt.

SIMULATORS

Another development by the Bell electronics division which we were able to sample was a helicopter simulator with a visual representation of the changes of scenery that the pilot would see when flying, as he operates his controls. This simulator has been built primarily as a research tool, but is expected to have valuable potentialities for pilot training in hovering flight near the ground and in auto-rotative flight.

The simulator consists of three main components—a projector, a pilot's compartment, and a computer. The landscape is built in miniature on a 6 ft. square plastic transparency above the pilot's head, and is projected on to a hemispherical screen; control movements which would cause directional and attitude changes of the helicopter are arranged, through the computer, to displace the transparent landscape appropriately. Control movements affecting altitude raise or lower the projector to give the corresponding effects on the screen. It is an interesting psychological phenomenon that, in "turns" and "descents" there is a sensation of acceleration that is, in fact, completely imaginary; the equipment does not simulate physical acceleration, although vibration, engine and rotor noise, rough air, and control forces are provided.

The Curtiss-Wright Corporation, generally thought of in connection with engines and propellers, but with many ramifications in the metallurgical, plastics, and instruments fields, also have an entire division devoted to electronics. Flight simulators, principally for long-range transport and bomber aircraft, are one of their main activities.

HIGH-TEMPERATURE PLASTICS

Turning to another field, the Plastics Division of Curtiss Wright has developed a high-strength high-temperature glass-reinforced phenolic resin with interesting characteristics. The mechanical properties are given in the accompanying table.

This new weight-saving material has been used in a jet-engine compressor stator case and for jet-engine compressor blades at temperatures up to 500 deg. F. It has relatively high damping characteristics, which eases fatigue problems under vibratory loading, and it is, of course, corrosion resistant. It is much less costly to manufacture than similar metal parts, particularly for complex shapes, and a high surface smoothness can be obtained. By suitably orienting the glass fibre direction it is possible to design for local stress conditions.

Among other aspects on which it is not possible to dwell now, it should be mentioned that Boeing and Solar are producing small auxiliary gas turbines; that Boeing claim to have developed the most advanced ramjets in the United States; and that Lockheed have a department specialising on the development of airport loading facilities. In subsequent articles we shall describe some of the research and production highlights that were brought to our notice.

Properties of High-Strength Plastic

	Room Temperature	500 deg. F.
Ultimate tensile strength, lb. per sq. in.	60,000–70,000	40,000–50,000
Tensile modulus of elasticity, million lb. per sq. in.	4–5	4–5
Compressive strength, lb. per sq. in.	40,000–50,000	30,000–35,000
Impact strength, Izod ft. lb./in. notch	14	13
Specific gravity	1·7–1·9	—

HIGH PRESSURES

PROPERTIES OF MATTER AND DESIGN OF EQUIPMENT

A review of some recent work on the physical properties of matter under high pressure was the subject of the 42nd Thomas Hawksley Lecture delivered at the Institution of Mechanical Engineers on November 18 by Professor D. M. Newitt, M.C., D.Sc., F.R.S.

Professor Newitt discussed problems involved in the measurement of high pressure, and the design of high-pressure equipment. He also reviewed the results of work on the pressure-volume-temperature surface, including the surfaces representing the gaseous, liquid and solid states, and the behaviour of binary systems at high pressure. Particular reference was made to the experimental work on the properties of steam which is being carried out at the Imperial College of Science.

PRESSURE-VOLUME-TEMPERATURE SURFACE

The data on the pressure-volume-temperature surface of the more important industrial gases are very limited, the majority of the information being restricted to the temperature range −100 to 400 deg. C. and a maximum pressure of 3,000 bars.* In the case of steam the International Steam Table Conference of 1929 encouraged much international work on the properties of steam, and a third conference in 1934 prepared International Skeleton Tables covering the range of temperatures up to 550 deg. C. and pressures up to 350 atmospheres. There is now, however, an urgent need for an extension of the Skeleton Tables for boiler and turbine design.

Since 1934 there has been a limited amount of data published which gives some information at pressures up to 2,500 atmospheres and for a maximum temperature of 1,000 deg. C. At present, work is being carried out at the Imperial College of Science in which pressure, total heat and temperature measurements are being made in the pressure range 350-1,000 atmospheres and at temperatures up to 600 deg. C., and it is hoped to extend the temperature limit to 750 deg. C., but only at reduced pressures. These measurements are being made with an electrically-heated flash-boiler which produces steam whose temperature and pressure are measured before it is exhausted adiabatically into a calorimeter condenser. The pressure is measured with a free-piston pressure balance and the temperature by a platinum resistance thermometer.

On the P, V, T, surface the liquid state is defined, as shown in Fig. 1, by an area bounded by the melting and bubble lines and the isotherm through the critical point, and there are in addition two regions in which liquid and solid, and liquid and gas coexist. Fig. 1 gives the P, V, T, surface for helium, which has two liquid phases of equal density but different transport properties. The upper boundary of the liquid region and the melting curve are at extremely high pressures, well beyond experimental observation, and theory does not indicate how it should terminate.

Data exist on the compressibility of a wide range of liquids up to pressures of 30,000 bars, but only over a small temperature range. The compressibility is considerably reduced at high

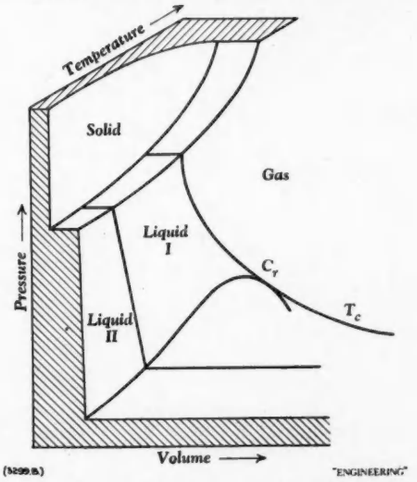
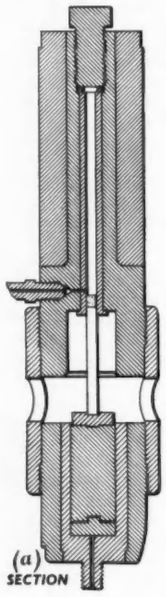


Fig. 1 Pressure-volume-temperature surface for helium.

* 1 bar = 10^6 dynes per sq. cm. = 0·987 atmosphere = 14·5 lb. per square inch = 0·9807 Kg. per sq. cm.

pressure, and the effect of differences in the structure of the molecule on the compressibility also becomes less marked. There is no satisfactory theoretical equation for correlating compressibility data at constant temperature over a wide pressure range, but the empirical Hudleston equation has been found to represent accurately the P, V, T, relationship for all the liquids which have been investigated at Imperial College.

Regions of coexisting solid and liquid, and solid and gas phases appear on the P, V, T surface as narrow shelves, as shown in Fig. 1. The melting curve can be derived from the P, V, T measurements by using Clapeyron's equation, though the considerable rise in the viscosity of liquids at pressure makes it very difficult to explore the upper end of the curve. The compressibility of most solids decreases with pressure though in some cases there are discontinuous changes in the compressibility pressure curve probably caused by a change in the crystalline structure or a rearrangement of the electrons in the molecule. At extreme pressure of 10^6 and 10^8 bars theory indicates that all matter would disintegrate; the results of experiments at the pressures at present achievable would seem to support this conclusion.



MEASUREMENT OF HIGH PRESSURE

The most usual form of secondary pressure gauge for pressures up to and greater than 10,000 bars is one in which the change of electrical resistance with pressure is measured. Manganin is particularly suitable for this purpose as it has a low temperature coefficient of resistance at room temperature, and its change of resistance with pressure is very nearly linear. Primary gauges are either a balanced free piston or a mercury column; either of these is limited to pressures at which the containing cylinder remains elastic. This condition at present limits the maximum pressure which can be measured to 12,000 bars.

In the balanced free-piston gauge the end thrust on a piston subjected to the pressure is measured. For accuracy the changes in dimensions with pressure must be allowed for and also the viscous drag on the piston caused by leakage. The viscous drag effectively increases the diameter of the piston. To determine the errors in such gauges a mercury column has recently been constructed at Imperial College. This is shown diagrammatically in Fig. 2. In operation, the two piston gauges are alternately connected to the bottom and top of the mercury column, which is 30 ft. long, so that pressure can be raised in increments equivalent to the length of the mercury column. The mercury column is maintained at a constant temperature within $\pm 0{\cdot}02$ deg. C., and corrections are applied to allow for the compressibility of mercury and of the paraffin in the pipes connecting the top of the column to the dead-weight tester.

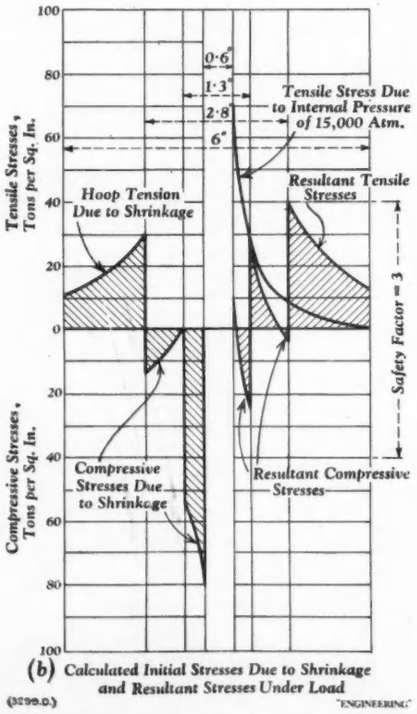
The Manganin gauge can be compared with a free-piston gauge up to a pressure of about 12,000 atmospheres. Above this pressure the calibration of the Manganin gauge can only be obtained by extrapolation, though the transition pressure for bismuth has been determined with an accuracy of better than 6 per cent. by Bridgman, giving a check point at about 25,000 bars.

DESIGN OF HIGH-PRESSURE EQUIPMENT

Normally high pressures are produced by compressing a fluid in a cylinder by means of a piston. As long as the cylinder remains elastic then the stress distribution can be determined. Simple, compound and wire-wound cylinders have been satisfactorily designed for industrial and experimental purposes. The maximum pressure which can be contained is limited by the yield strength and by the bore stress at zero pressure, which may be very high in a compound cylinder design as is shown in Fig. 3. Several cylinders designed for 7,000 bars have been used for many years with no signs of permanent deformation or fatigue failure. At higher pressure, failure mostly occurs in the cylinder just behind the piston head, due to the stress gradient at this point caused by the change in pressure at the bore from some high value to zero. This particular weakness can be improved by using an autofrettaged cylinder. To reach higher pressures it is necessary to use much larger overstrains than have normally been used in autofrettage practice, and frequent checks on the dimensions are then required for safety.

Bridgman has reached pressures of 50,000 kg. per square centimetre by using the construction shown in Fig. 4. As the load is applied to the piston the cylinder is pushed into the massive block shown and is subjected to an increased radial compression. The block has a very large wall thickness, and even if it yields at the interface the outer layers are still elastic. Bridgman has reached pressures of 100,000 bars by adopting a cascade arrangement in which a number of vessels are placed one inside the other, each being subjected to an external pressure in addition to the internal pressure.

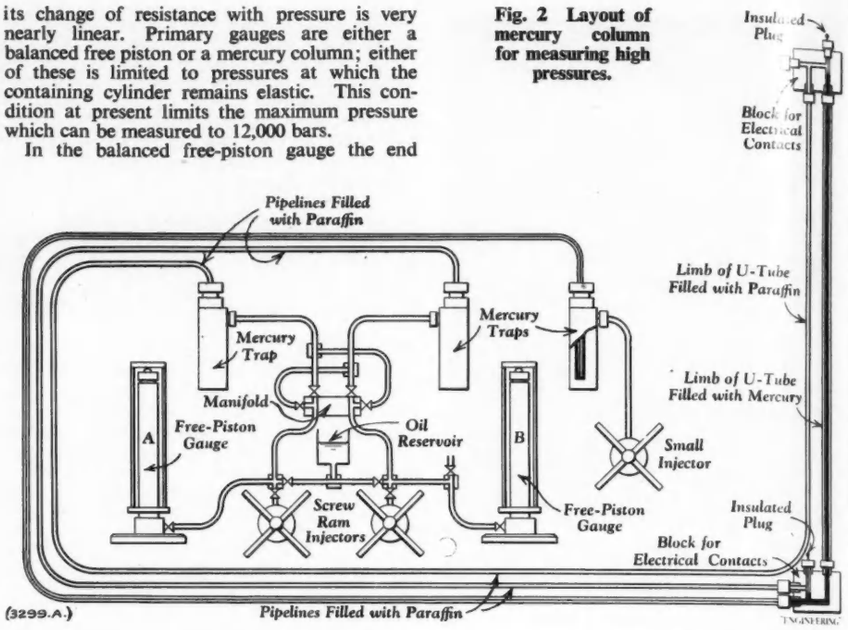
Designers of high-pressure equipment normally assume that hydrostatic pressure does not affect the yield and flow of metals. This assumption is also important in the theory of plasticity. Much experimental work has been carried out on this topic, and except for one published paper the conclusion has been reached that high fluid pressure has very little influence on the stress-strain diagram of most metals in tension or torsion. At extremely high pressures the stress-strain diagram is slightly raised. The important effect of pressure is that the strain to failure is very considerably increased for most materials, the natural strain at failure being very nearly a linear function of the hydrostatic pressure.



(b) Calculated Initial Stresses Due to Shrinkage and Resultant Stresses Under Load

Fig. 3 Compound cylinder designed to withstand a pressure of 15,000 bars.

Fig. 2 Layout of mercury column for measuring high pressures.



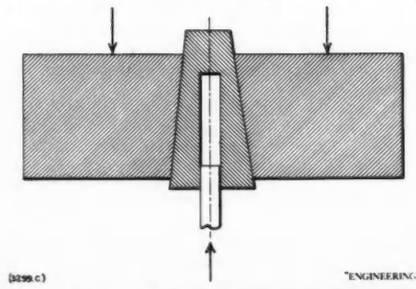


Fig. 4 Compound pressure vessel with conical inner core. While the pressure is rising with the thrust of the piston, the inner core is forced into the retaining jacket, and thus the external support depends on the internal pressure.

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TELEVISION AT PONTOP PIKE

The permanent television station of the British Broadcasting Corporation at Pontop Pike, near Newcastle-upon-Tyne was opened on Tuesday, November 15. It has an effective radiated power of 12 kW (vision) and 3 kW (sound) from a 500 ft. aerial and uses the 66·75 megacycle channel for vision and the 63·25 megacycle channel for sound, the transmissions being horizontally polarised.

ADHESIVE WEIGHT REDUCED BY EFFECTS OF TRACTION FORCES

DESIGN OF ELECTRIC BOGIES FOR LOCOMOTIVES

By E. H. Croft, A.M.I.C.E., M.I.E.E.*

Most electric or Diesel-electric locomotives to-day are of the double-bogie type, this form of construction having superseded the fixed-frame type except for a few special applications. Some undesirable features of earlier bogie locomotives have been overcome, and designs are now available having excellent riding properties. Since the coupling of wheels, in most cases, is no longer acceptable due to the complications and extra maintenance it involves, the question of weight transfer, caused by tractive forces, becomes of major importance, and bogie locomotives must be designed to keep this transfer to an absolute minimum. Variations in bogie design, axle equalisation, methods of motor mounting, and support of the body on the bogie can cause weight transfer to vary from under 10 *per cent. to almost* 30 *per cent. at high starting tractive efforts.*

ELEMENTARY THEORY

Consider a simple vehicle having two axles, both driven, as indicated in Fig. 1.

Let H be the height of the centre of gravity,
Z the tractive effort,
L the wheel-base,
R the wheel radius,
$\frac{M}{2}$ the load per axle.

In such a case the tractive-force moment is ZH; the leading axle will be unloaded by $\frac{ZH}{L}$ and the rear axle loaded by the same amount. The term $\frac{ZH}{L}$ is referred to as the weight transfer.

It will be noted that H is the height of the centre of gravity for an individual vehicle, but if such a vehicle draws others, then the tractive effort required for propelling the vehicle is associated with the height of the centre of gravity, whereas the tractive effort required to propel the trailing load is associated with the drawgear height. Reference will be made to this again, but for simplicity in considering locomotives H will be regarded as the height of the drawgear. This assumption, as far as locomotives are concerned, introduces only small inaccuracies. It must not, however, be assumed for multiple-unit stock.

Consideration of actual bogie-locomotive designs is complex, and for convenience the writer splits the total weight transfer into four main components, namely: unsprung axle component, sprung axle component, bogie component, and body component. The reasons will be appreciated later.

A double-bogie locomotive as indicated in Fig. 2 may have varying values of A_1, A_2, B_1 and B_2 depending on the design, but obviously

$$A_1 \times \left(\frac{B}{2}+\frac{L}{2}\right) + A_2\left(\frac{B}{2}-\frac{L}{2}\right) + B_1\left(\frac{B}{2}-\frac{L}{2}\right) + B_2\left(\frac{B}{2}+\frac{L}{2}\right)$$

must equal ZH.

Obviously the minimum weight transfer for a given tractive effort will result when $-A_1 = -A_2 = +B_1 = +B_2$.

In all considerations care must be taken of signs. In this article motion is assumed to be towards the left; forces acting downwards are considered positive, and upwards negative. Clockwise moments are positive and anti-clockwise moments negative. In dealing with the problem the following terms will be found of use:—

Nominal Adhesion: the ratio of tractive effort to adhesive weight regardless of weight transfer. It will generally be expressed as a percentage.

True Adhesion: the ratio of tractive effort to an adhesive weight equal to the weight on the most unloaded axle, multiplied by the number of driving axles.

True adhesion is the only indication of the adhesive characteristic of a locomotive when not provided with coupling rods. Thus:—

$$\text{Nominal adhesion} = \frac{Z}{M} \times 100,$$

where Z and M are tractive effort and adhesive weight respectively, and:—

$$\text{True adhesion} = \frac{Z}{\left(\frac{M}{N} - W\right) \times N} \times 100,$$

where N is the number of axles and W the maximum negative weight transfer.

The ratio $\frac{\text{True adhesion}}{\text{Nominal adhesion}}$ is a sound indication of the adhesive properties of a locomotive design. Since, for a given design, it will vary with the tractive effort, it must be expressed at a fixed tractive effort. The writer fixes this at 25 per cent. of the adhesive weight, and regards the ratio as adhesion efficiency.

TWO-AXLE BOGIES

It has been mentioned that weight transfer is mainly influenced by: (*a*) motor mounting; (*b*) system of axle equalisation; (*c*) bogie design; (*d*) method of carrying body on bogies. To illustrate these points various examples will be taken, based first upon a locomotive with two two-axle bogies, and later on one with two three-axle bogies.

For the two-axle bogie locomotive the following approximate data will be assumed:—

Axle-load = 20 tons.
Wheel diameter = 50 in.
Bogie wheel-base = 138 in.
King-pin distance = 282 in.
Motor mounting base = 48 in. for axle-hung motors.
Tractive force = 20 tons or 44,800 lb.
Drawgear height = 42 in.

The motor mounting base for the axle-hung motor is the distance from the nose mounting centre-line to the axle centre-line. It is assumed that this base is horizontal. In cases where it is not, detail complications exist which will alter the axle components.

The tractive effort of 20 tons is a convenient figure as it corresponds to 25 per cent. nominal adhesion, which is taken as a basis for all calculations and adhesion efficiency. The following examples for two-axle bogies are shown diagrammatically in Table I on page 792.

Example 1.—In this case the motors will be assumed to be spring-borne and not axle-hung. The body will be assumed to rest on the bogies on bearers fore and aft of the king-pins and the axles of each bogie will be fully side-equalised.

The axle will have no unsprung component as the motor is rigidly fixed to the bogie frame, and does not have one end resting direct on the rails via the wheels and axles. Thus both axle component moments are transmitted direct to the bogie frame, on both bogies. Since the body is supported on the bogies by means of fore and aft bearers, any resultant moments on the bogie must be transmitted to the body, and body and bogies function as one unit so far as weight transfer is concerned. Since each bogie is fully side-equalised, all axles will have the same value of weight transfer, the forward pair being negative and the rear pair positive.

In this case the calculation is simple and there is no need to consider the various components separately.

$$\text{Weight transfer} = \frac{44{,}800 \times 42}{282 \times 2} = 3{,}336{\cdot}2 \text{ lb.}$$

$$\text{Adhesion efficiency} = \frac{20 - \frac{3{,}336{\cdot}2}{2{,}240}}{20} \times 100 = 92{\cdot}5 \text{ per cent.}$$

Example 2.—As many designs of locomotives still embody axle-hung motors, the spring-borne motors of Example 1 will be considered as axle-hung and the case re-examined.

The unsprung component reacts directly on the axle and must be considered separately.

$$\text{It is } \frac{44{,}800}{4} \times \frac{25}{48} = 5{,}833{\cdot}3 \text{ lb.}$$

(This value will be negative on the forward axle, positive on the second axle, negative on the third, and positive on the rear axle.)

The sprung axle components form a couple equal to 5,833·3 lb. multiplied by the distance between the nose suspensions, namely 42 in. This is anti-clockwise and therefore negative. As in Example 1, any bogie reaction must be associated with the body. Thus the value of the sprung axle component becomes:—

$$\frac{5{,}833{\cdot}3 \times 42 \times 2}{282 \times 2} = 868{\cdot}8 \text{ lb.}$$

This will be positive on the forward axle, positive on the second axle, negative on the third and negative on the rear axle.

$$\text{The body component is } \frac{44{,}800 \times (42 - 25)}{282 \times 2}$$

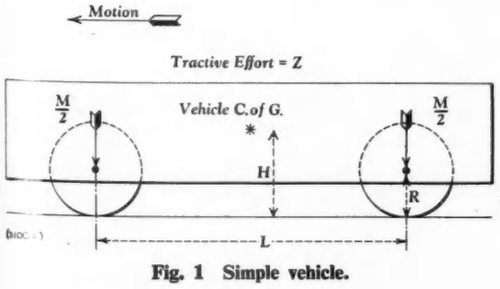


Fig. 1 Simple vehicle.

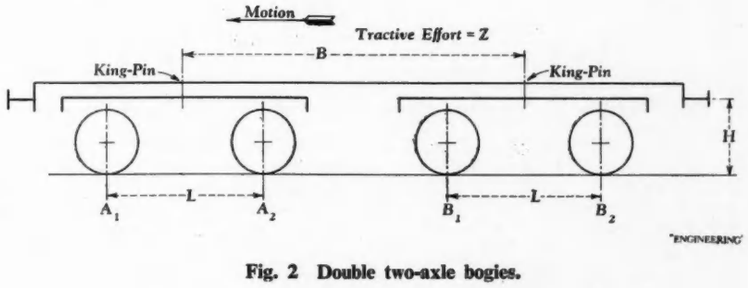


Fig. 2 Double two-axle bogies.

= 1,350·3 lb., being negative on both axles of the forward bogie, and positive on the rear bogie. If these various values are algebraically added together, the following weight transfers are obtained:—

Forward axle: − 6,314·8 lb.
Second axle: + 5,351·8 lb.
Third axle: − 5,351·8 lb.
Rear axle: + 6,314·8 lb.

The resultant adhesion efficiency is

$$\frac{20 - \frac{6,314 \cdot 8}{2,240}}{20} \times 100 = 86 \text{ per cent.}$$

Comparison of these two examples illustrates the variation that occurs. Example 1 represents a better locomotive from the point of view of maximum tractive effort. The obvious fact that the algebraic sum of the moments of total weight transfer of each axle about the locomotive centre must equal ZH forms a useful mathematical check and should always be applied to complicated cases.

Example 2 shows the disadvantages of the axle-hung motor. It is desirable, therefore, to consider steps to lessen or remove the disadvantage. In Example 2, bogies and body function as a unit, thus the sprung axle component is associated with the king-pin distance, and does not have such a beneficial effect on the unsprung component. For *Example* 3, therefore, a design will be considered in which the king-pins have spherical seatings and the fore and aft bearer is removed. The axle equalisations will have to be removed, as otherwise the bogie would be unstable, but on a two-axle bogie the axles will still divide the load.

The unsprung axle component will remain at 5,833·3 lb., but the sprung axle component will now be associated with the bogie wheel-base and will be increased to 1,775·3 lb. Reference to Table I will at once show the benefits of this on the total axle components.

The removal of the fore and aft bearers causes the bogies to operate separately as powered vehicles. For simplicity the bogie thrust point will be assumed to be at drawgear height. This results in the bogie component being high at 2,759·4 lb. and the total weight transfer being 6,817·4 lb. as shown in Table I. At an adhesion efficiency of 84·8 per cent., Example 3 is less desirable than Example 2.

From the above it is obvious that the bogie thrust point should be lowered, and some modern designs of bogies embody such a feature. For simplicity the thrust point will now be considered at axle height, thereby reducing the bogie component to zero. The resultant values are shown in *Example* 4, there being a definite improvement in adhesion efficiency to 88 per cent.

Example 5 illustrates the importance of side-equalisation, or the equivalent. For simplicity consider Example 1 in which the axle equalisation has been omitted. Provided the road springs have been adjusted, the weight transfer per axle

Table I Analyses of various arrangements of two-axle bogies.

	Example 1 *Spring-Borne Motors* *Fore and Aft Bogie Bearers* *Axles Equalised*	*Example 2* *Axle-Hung Motors* *Fore and Aft Bogie Bearers* *Axles Equalised*	*Example 3* *Axle-Hung Motors* *No Fore and Aft Bogie Bearers* *No Side-Equalisation* *Bogie Thrust Point at Drawgear Height*	*N* *Th*
	○ ○ ○ ○	○ ○ ○ ○	○ ○ ○ ○	○ ○
Unsprung Axle Component	None	5833·3 5833·3 / 5833·3 5833·3	5833·3 5833·3 / 5833·3 5833·3	5833·3 5833·3
Sprung Axle Component	1985·8 1985·8 1985·8 1985·8	868·8	1775·3 1775·3 / 1775·3 1775·3	1775·3 1775·3
Total Axle Component	1985·8 1985·8 1985·8 1985·8	4964·5 6702·1 / 6702·1 4964·5	4058 4058 / 4058 4058	4058 4058
Bogie Component	None	None	2759·4 2759·4 / 2759·4 2759·4	
Body Component	1350·4 1350·4 1350·4 1350·4	1350·3 1350·3 1350·3 1350·3	None	1350·3 1350·3
Total Transfer	3336·2 3336·2 3336·2 3336·2	6314·8 5351·8 / 5351·8 6314·8	6817·4 6817·4 / 6817·4 6817·4	5408·3 5408·3
Adhesion Efficiency, per Cent.	92·5	86	84·8	

(3100 D)

	Example 1 *Motors Spring-Borne* *Fore and Aft Bearers* *Full Side-Equalisation*	*Example 2* *Motors Spring-Borne* *No Fore and Aft Bearers* *No Equalisation* *Bogie Thrust at Drawgear Height*	*Example 3* *Motors Spring-Borne* *No Fore and Aft Bearers* *No Equalisation* *Bogie Thrust at Axle Height*	*Axles)*
	○ ○ ○ ○ ○ ○	○ ○ ○ ○ ○ ○	○ ○ ○ ○ ○ ○	○ ○ ○
Unsprung Axle Component	None	None	None	5833 5833
Sprung Axle Component	Reacts on Body	Included in Bogie	4667 4667 / 4667 4667	
Bogie Component	Reacts on Body	7840 7840 / 7840 7840	None	
Body Component	2556 2556 2556 2556 2556 2556	None	1035 1035 1035 1035	3277 3277
Total Transfer	2556 2556 2556 2556 2556 2556	7840 7840 / 7840 7840	5702 3632 5702 / 3632	2556 2556
Adhesion Efficiency, per Cent.	94·3	82·5	87·3	

(3100E)

will vary as its distance from the locomotive centre. Let O be the weight transfer on the outer axles, and I that of the inner; then:—

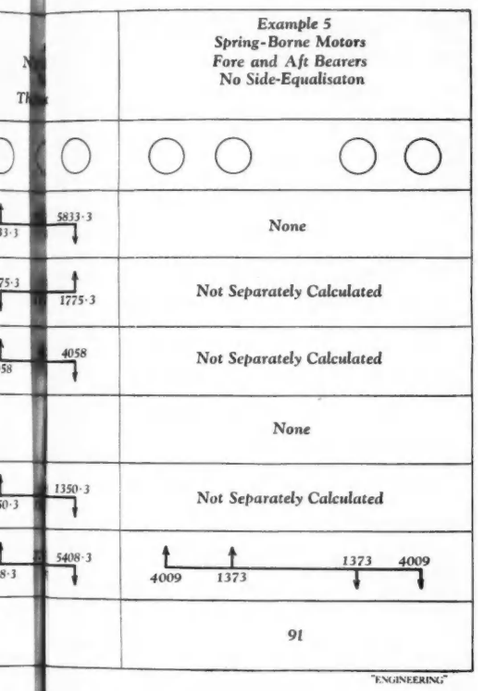
$$O \times (282 + 138) + I\,(282 - 138) = ZH = 1{,}881{,}600.$$

and $\frac{O}{I} = \frac{210}{72}$

From which O = 4,009 and I = 1,373.

The additional weight transfer in this case only reduces the adhesion efficiency to 91 per cent. instead of 92·5 per cent., but illustrates the advantage of side-equalisation. It must also be appreciated that side-equalisation divides the sprung load on the axles regardless of road spring variations.

The calculations of these five simplified examples show the complexity of the problem and give an indication of the way in which well-known design features of locomotives can influence weight transfer.



GENERALISATIONS FOR TWO-AXLE BOGIES

The following generalisations derived from the foregoing analysis may be of assistance:—

(1) The longer the bogie wheel-base and the king-pin distance, the greater the possibility of a high adhesion efficiency.

(2) For the dimensions considered, Example 1 represents the maximum adhesion efficiency.

(3) When all weight-transfer component moments can be transmitted to the body, the king-pin distance is the essential feature. This is only possible with spring-borne motors.

(4) With axle-hung motors there is considerable advantage in a low bogie thrust point (compare Example 4 with 2 and 3).

(5) Two-axle bogies without fore and aft bearers, and no side-equalisation, still divide the sprung axle load.

(6) In most cases weight transfer is increased by mounting the drawgear on the bogie, as each bogie then operates as a separate power unit. Further, such an arrangement results in a bogie of high moment of inertia in a horizontal plane, often creating bad riding and wear of track.

THREE-AXLE BOGIES

The investigation of the locomotive with two three-axle bogies will be based on the following data:—

Axle-load	.. ..	20 tons
Wheel diameter	.. ..	50 in.
Motor mounting base	..	48 in.
Tractive force	.. ..	67,200 lb.
Drawgear height	.. ..	42 in.

In this case axle-hung motors may be arranged in two main ways (see Figs. 3*a* and *b*), and the axle distances will vary slightly, but for convenience the king-pin distance has been assumed the same in both cases. All required dimensions are shown in the figures.

Example 1 (Table II) is one in which all motors are spring-borne, bogies provided with fore and aft bearers and axles on each bogie fully side-equalised. In such a case there is no need to calculate the weight-transfer components separately since all component moments are transmitted to the body.

Thus if *w* be the weight transfer per axle, then:—

$$w\,(274 + 184 + 94)2 = 67{,}200 \times 42$$

and *w* becomes 2,556·5 lb., being negative on the forward bogie and positive on the rear.

The resulting adhesion efficiency is 94·3 per cent.

Obviously, with fully spring-borne motors their arrangement in the bogie is of no consequence since there is no unsprung axle component.

For *Example* 2 the fore and aft bearers will be removed, and obviously this means the removal of full side-equalisation. This example will be based on a bogie with no form of side-equalisation. Later consideration will be given to side-equalising two axles per bogie only.

The axle component moments of all three motors will now react on the bogie, and not on the body, and will be:—

$$33{,}600 \times 25 = 840{,}000 \text{ lb.-in.}$$

If the bogie thrust point be assumed to be at drawgear height, then the bogie component moment is 33,600 × 17 = 571,200 lb.-in. Together they equal 1,411,200 lb.-in.

Let W_1, W_2 and W_3 be the weight transfers for the first, second and third axles of the forward bogie respectively. Since the first and third axles are equidistant from the second:

$$W_3 = -W_1 \quad \text{and} \quad W_2 = 0$$

Therefore $W_3 \times 180 = 1{,}411{,}200$ lb.-in.; $W_3 = 7{,}840$ lb., and $W_1 = -7{,}840$ lb.

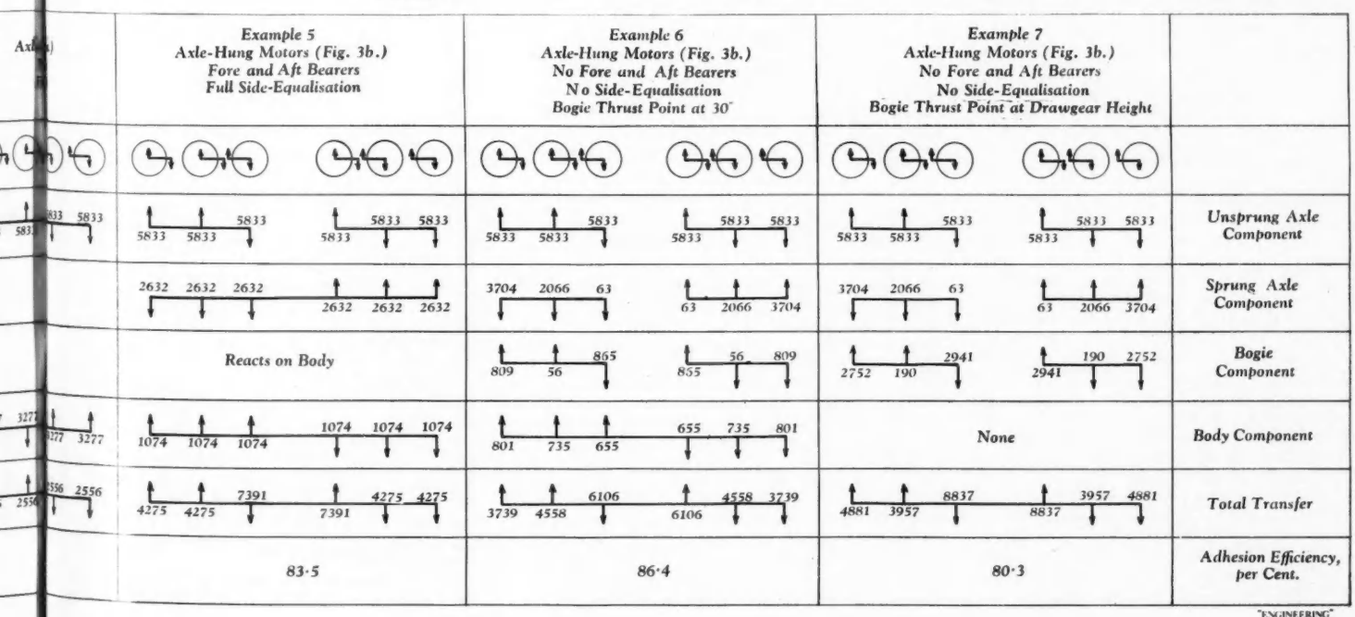
The body component will be zero due to the fact that the bogie thrust point is at drawgear height. Thus the adhesion efficiency becomes 82·5 per cent. This clearly illustrates the advantages of fore and aft bearers in certain cases.

In *Example* 3 the bogie thrust point will be lowered to the axle height, other conditions remaining as in Example 2. In this case the moment of 840,000 lb.-in. only is directly associated with the bogie, and the weight transfer due to this is: No. 1 axle, − 4,666·7; No. 2 axle, 0; No. 3 axle, 4,667·7.

The body component moments, namely 67,200 × 17 lb.-in., will result in a weight transfer of $\frac{67{,}200 \times 17}{3 \times 2 \times 184}$ lb. on each axle, negative on the axles of the forward bogie and positive on the rear. This value is 1,034·8 lb. This results in a maximum weight transfer of 5,701·5 lb. and an adhesion efficiency of 87·3 per cent., showing an increase as compared with Example 2, but a decrease as compared with Example 1.

Before passing to the examination of the axle-hung motor, it is of interest to consider how low the bogie thrust point should be to allow the efficiency of Example 3 to equal that of Example 1. Example 1 has a high efficiency due to the fact that all axles share equally the

Table II Analyses of various arrangements of three-axle bogies.



total weight transfer. Obviously, to do this there must be no resultant moment on the bogie, i.e., the sum of the bogie component and the axle components per bogie must be zero. To obtain this, the bogie thrust point must be at rail level, which is impossible. The arrangement of Example 1 would so far seem the most suitable, but later it will be shown that the same result is possible with axle-hung motors.

Where axle-hung motors are adopted they are generally arranged as shown in Fig. 3 *a* and *b*. *Example* 4 will be assumed to be similar to Example 1 with the exception that the motors are axle-hung as indicated in Fig. 3*a*. The unsprung axle component is equal to $\frac{11,200 \times 25}{48}$ lb., namely 5,833·3 lb. It will be negative on all forward bogie axles and positive on all rear bogie axles.

The unsprung axle component moment will be associated directly with the body and will have a value of 5,833·3 (46 + 136 + 226) × 2; namely, 4,760,000 lb.-in. To this amount must be added algebraically the body component of + 67,200 × 17 lb.-in., i.e., 1,142,400 lb.-in.

The weight transfer due to the above and the unsprung component is 2,556·5 lb. per axle, being negative on the forward bogie axles and positive on the rear bogie axles. This and the adhesion efficiency of 94·3 per cent. are identical to Example 1. This may seem surprising when viewed in the light of the two-axle double-bogie examples, but is due to the fact that the unsprung component is of the same sense on all three axles of a bogie. Due to the high adhesion efficiency, this type of locomotive, as well as that considered in Example 1, is very suitable for heavy freight services, so long as track curvature is not excessive.

Many locomotives have had the axle-hung motors arranged as shown in Fig. 3*b*. This will now be considered as *Example* 5. Fore and aft bearers, with full side-equalisation of axles, will be assumed.

The unsprung axle component is, as in Example 4, 5,833·3 lb., but in this example it is negative on the first, second and fourth axle from the forward end and positive on the third, fifth and sixth. The moments of the sprung axle components will be associated with the body. Let the weight transfer per axle be *w*. Then:—

$$w\,(274 + 184 + 74) = 5,833{\cdot}3\,(226 + 136 - 122),$$

from which w = 2,631·6 lb. This value will be positive on all axles of the forward bogie and negative on the rear.

If the body component be B per axle then B × 532 = 33,600 × 17; or B = 1,073·7 lb., being negative on the axles of the forward bogie and positive on the rear.

These components added algebraically result in a maximum weight transfer of 7,391·2 lb., which corresponds to an adhesion efficiency of 83·5 per cent. or a loss of about 11 per cent. as compared with Example 1 and the previous example. For this reason the author considers that such an arrangement of motor suspension is undesirable for most applications.

It is obviously impossible to give examples of every possible variation of motor mounting, axle equalisation and provision of bearers, but to emphasise the benefits of splitting up total weight transfer into the various components *Example* 6 will be considered, having motors mounted as in Fig. 3*b*, no fore and aft bearers, and no equalisation, but a bogie thrust point at 30 in. The unsprung axle component will be 5,833·3 lb. as in the last example, and also have the same signs.

The sprung axle component is associated with the bogie. Let the values for the first, second and third axles of the forward bogie be W_1, W_2, $2W_3$. Then W_1 and $W_2 + W_3$ = 5,833·3 lb. (since the sprung and unsprung axle components together must be equal to zero).

Further, $W_2 \times 110 - W_1 \times 200 = 5,833{\cdot}3\,(48 - 62 - 152)$ (since the sum of the moments must equal zero), and $\frac{W_1 - W_2}{W_2 - W_3} = \frac{90}{110}$, resulting from equal road springs to each axle (See Fig. 4).

From the above equations the sprung axle components will be found to be 3,704·1, 2,065·8 and 63·4 lb. respectively from front to rear of the forward bogie, and be − 63·4, − 2,065·8 and − 3,704·1 lb. respectively from front to rear of the rear bogie. The bogie component is due to the thrust point being 5in. above axle level. This value is chosen to illustrate the effect, regardless of whether it is practical in application.

Let W_1, W_2 and W_3 be the weight transfers for the first, second and third axles of the forward bogie. The rear bogie will have the values reversed in sequence and sign.

$W_1 + W_2 + W_3 = 0$, since there can be no increase in weight. $\frac{W_1 - W_2}{W_2 - W_3} = \frac{90}{100}$ as in the previous example.

$$-W_1 \times 200 - W_2 \times 110 = 5 \times 33,600 \text{ lb.-in.}$$

From the above equations, W_1 = − 809·1 lb.; W_2 = 55·8 lb.; W_3 = + 864·9 lb.

Finally, the body component. The change of load on the bogies can only react through the king-pin seatings and this load, negative on the forward bogie and positive on the rear bogie, will have a value of $\frac{67,200 \times 12}{184 \times 2}$ or 2,191·3 lb.

Let W_1, W_2 and W_3 be the negative weight transfer per axle on the forward bogie. On the rear bogie the sequence and signs will be reversed. Then:—

$$W_1 + W_2 + W_3 = -2,191{\cdot}3 \text{ lb.}$$

$$\frac{W_1 - W_2}{W_2 - W_3} = \frac{90}{110}$$

and $W_1 \times 200 + W_2 \times 110 = -2,191{\cdot}3 \times 110$.

From the above:—W_1 = − 800·8 lb.; W_2 = − 735·3 lb.; W_3 = − 655·2 lb. The total weight transfer per axle is shown in Table II, the maximum being 6,106·4 lb., resulting in an adhesion efficiency of 86·4 per cent.

This shows the advantage of lowering the bogie thrust point but indicates the disadvantage of this arrangement of motor suspension. *Example* 7 illustrates the effect of a high bogie thrust point, i.e., taken at drawgear height.

GENERALISATIONS FOR THREE-AXLE BOGIES

The above simplified examples show that:—

(1) High adhesion efficiencies are obtainable with C_0-C_0 designs (Examples 1 and 4).

(2) With correct design of bogie there is no advantage in spring-borne motors as compared with axle-hung motors (Examples 1 and 4) so far as weight transfer is concerned.

(3) Axle-hung motors should be arranged so that all unsprung components on a bogie have the same sense, and this sense is negative on the forward bogie and positive on the rear (Examples 4 and 6).

(4) In most cases fore and aft bearers are a very great advantage (Examples 1, 2 and 3), but where motors are mounted as Fig. 3*b* they may be a disadvantage (Examples 5 and 6).

(5) A low bogie thrust point is almost essential with some arrangements (Examples 6 and 7).

OTHER CONSIDERATIONS

Space permits only brief reference to many other examples of weight transfer, including methods of reducing or avoiding it.

Guiding or non-motored axles, of course, share the weight transfer, and the share they take depends on many factors, such as the type of bearers provided and the arrangement of side-equalisation. In certain arrangements of bogie locomotives having axle-hung motors, the guiding axles can take the whole weight transfer. It cannot, however, be regarded as ideal to have loads on guiding axles varying beyond a small amount, and in any case motoring all axles results, even with weight transfer, in greater total adhesive weight. Except for unusual service conditions, modern adhesive requirements demand that all axles be motored.

In the case of the six-axle locomotive the importance of motor arrangement has been indicated. This also has benefits in four-axle cases. For example, the four-axle bogie locomotive considered, if so arranged, would have an adhesion efficiency of 92·5 per cent., the value obtainable with spring-borne motors. Since the bogie design, to permit this arrangement, presents difficulties, it has rarely, if ever, been adopted. It may, however, be worthy of reconsideration.

It is common practice, and in most cases a desirable one, to spring the body to the bogie frame. In some such cases, both bearer springs and road springs, in combination, influence weight transfer. Not only is the calculation of weight transfer then extremely complex, but variations of springs and seatings in service can cause considerable changes. Such arrangements should be avoided, by suitably arranged side-equalisation, or in some cases by equalisation of the body bearers.

Where drawgear is carried on the bogie and the bogies are articulated for this reason, they

Fig. 3*a*

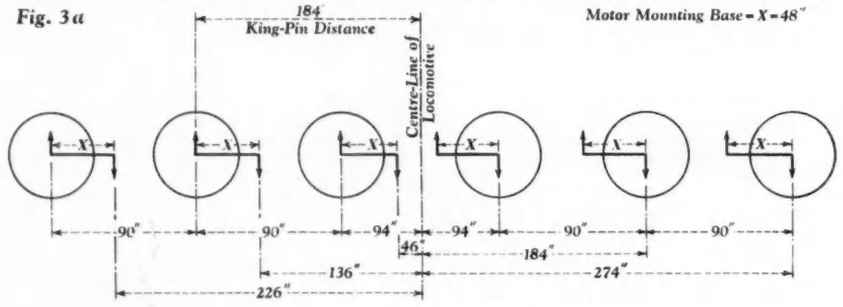
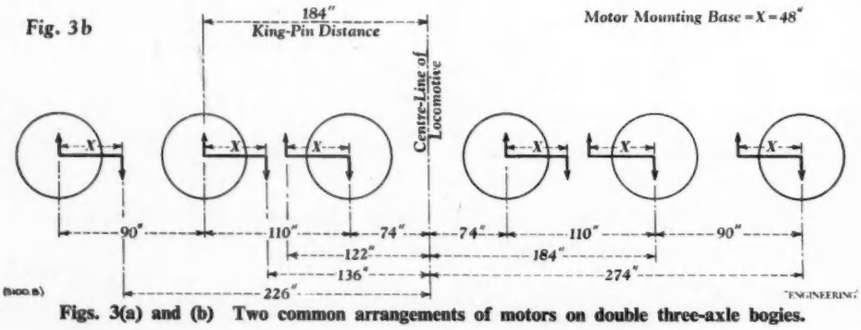


Fig. 3*b*



Figs. 3(a) and (b) Two common arrangements of motors on double three-axle bogies.

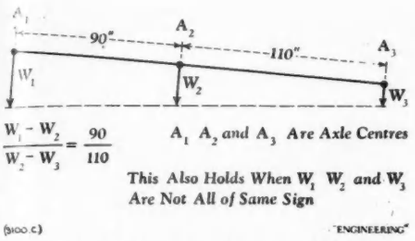


Fig. 4 Division of weight transfer loads between axles.

function as two separate units so far as weight transfer is concerned, and adhesion efficiency is low. While locomotives of this type have given excellent service, such designs cannot be considered in line with modern practice or adhesion demands.

By means of controlled bearers between body and bogie frame, the weight transfer can be reduced. Since this depends on automatic or semi-automatic control, it is not considered as good as designing the locomotive for minimum weight transfer, but can be of benefit where, for certain reasons, designs which are poor from the weight-transfer point of view have been adopted.

A further method is to vary the motor torque characteristic, so that it adjusts itself for the weight transfer. This has been of benefit in many cases, where somewhat orthodox designs of two-axle bogies have been adopted. Modern designs of bogies, even with axle-hung motors, are capable of giving as good results and are not subject to the amount of variation that may occur with motor field shunting.

Mention has been made of the effect of the centre of gravity of the complete locomotive. It is advisable to consider this when finally calculating the weight transfer, but in main-line locomotives it has little effect. For example, in one case of a locomotive of 54 tons handling trains of 300 tons, the increase in weight transfer amounted to about 3 per cent. or a reduction in adhesion efficiency of well under 1 per cent.

In the case of a two-axle bogie not provided with fore and aft bearers, the axle-load is equalised, although side-equalisation cannot be provided. In a three-axle bogie without fore and aft bearers, full side-equalisation is impossible but axle loading may be shared by side-equalising two axles only. This may be of benefit in some cases, but it must always be borne in mind that unsprung axle loads, due to axle-hung motors, are not influenced by equalisation, although it may influence the total of unsprung and sprung loads. While equalisation must be taken into account when considering weight transfer, its main function must always be regarded as contributing to riding properties, avoiding high bogie and main-frame stresses and reducing derailment risks.*

CONCLUSIONS

High tractive efforts required to-day both for starting and high-speed running, where the coefficient of friction is lowest, demand designs based on the very best characteristic of adhesion. The bogie locomotive has a great many advantages and is most suitable for electric propulsion. The problems of its bad riding properties and track punishment have been overcome. Many modern examples are excellent in this respect.

Adhesion seems to have received less attention, and wheel slip at starting and wheel spin at speed are still a cause of costly track and locomotive maintenance. Where the question of weight transfer has been carefully considered, locomotives of modern design have been produced having adhesion efficiencies of over 90 per cent., which may be regarded as satisfactory. There are some modern designs, however, in which weight transfer does not seem to have received adequate consideration, and examples of recent date may be found where the adhesion efficiency is only just above 80 per cent., which cannot be called a satisfactory figure.

For the bogie locomotive to be the complete success it deserves, the question of weight transfer must receive as much attention as riding properties. In all but exceptional cases non-motored axles must be avoided; motors, side-equalisation and body support must be arranged and co-related to reduce weight transfer to a minimum.

* "Axle Equalisation on Railways," *Diesel Railway Traction*, December, 1947, page 218.

POLAROGRAPHIC RESEARCH LABORATORY

APPARATUS FOR RAPID CHEMICAL ANALYSIS

The polarograph, now extensively employed for micro-analysis in medicine, science and industry, was invented by Professor J. Heyrovsky, of Prague, in 1923, and has since been employed extensively in laboratories throughout the world because of its simplicity, accuracy and convenience and more particularly because of the considerable time saving that results from its use. At the present time, owing to the acute shortage of highly skilled and experienced chemists, the polarograph is of special importance since it enables routine analyses to be carried out by less-skilled personnel. There is, however, still an unsatisfied demand for chemists having a useful knowledge of the operation of polarographs and capable of interpreting the results they provide. In some countries this demand has been met by the formation of groups of experts whose services are available to the different branches of science and industry that can benefit from the polarographic technique.

The earliest example of a specialist organisation of this kind was the Central Polarographic Institute of Czechoslovakia established in Prague by Professor Heyrovsky. This Institute is noted for its pioneering work in developing the theory of polarography and applying it to various problems in medicine and science, an outstanding contribution made there in 1936 having been the Brdicka test for the diagnosis of cancer, known as the Prague cancer reaction. This was followed by the establishment of similar groups in many other countries, and between them they have made many valuable contributions to scientific investigations and analytical chemistry in the fields of metallurgy and engineering, as well as in medicine.

PRINCIPLE OF APPARATUS

Most chemists are now generally familiar with the principles involved in the operation of the polarograph, but a very brief explanation of them may be appropriate here. A solution of several different metallic elements or salts is electrolysed in a cell in which the anode is a pool of mercury. The cathode usually consists of capillary tube from which small separate drops of mercury fall at short intervals, the mercury being supplied to the tube from a vessel which can be raised or lowered to adjust the time interval between the drops. This device ensures that the cathode surface is always clean. If a steadily increasing potential ranging from − 0·2 to + 2·4 volts is applied between the anode and cathode it is found that the resulting current does not increase uniformly but in a series of steps. The potential at which each step occurs corresponds to a particular metallic ion and the height of the steps, showing the increase in current, indicates the concentration. If the current and potential are plotted, it is thus possible to determine from the graph what elements are present in the electrolyte and the quantity of each.

Polarographs, we understand, were first made in this country at the Cambridge works of the Cambridge Instrument Company, Limited, 13 Grosvenor-place, London, S.W.1, having been supplied to users just before the outbreak of the second World War. Dr. G. Jessop, of the company's research department, has carried out a great deal of work in developing the iustruments and the methods of using them. The department, moreover, has always endeavoured to assist users in the solution of any problems that may arise in the course of their work, as well as to give advice with regard to new applications. As the number of instruments in use has grown, the volume of this class of work has increased to such an extent that it has not always been possible to give it the immediate attention that is obviously desirable and for this reason it was recently decided to set up a special research laboratory to be devoted exclusively to the development of polarographic equipment, and the solution of users' and other problems.

NEW CAMBRIDGE LABORATORY

This new laboratory, of which Mr. W. J. Parker, B.Sc., A.R.I.C., is in charge, was formally opened on Wednesday, November 16, by Professor Heyrovsky. The work carried on in it will be carefully co-ordinated with the programme of work which will continue in the main research department but its specialised services will be available to provide advice and assistance to firms and research workers.

At the opening ceremony, which was preceded by an informal luncheon at the University Arms Hotel, the guests were welcomed by Sir J. A. Barlow, Bt., G.C.B., K.B.E., chairman of the Board of the Company, and Dr. M. C. Marsh, M.A., head of the research department, gave a brief historical review of the work of his department on polarography.

In the laboratory, several examples of electrolytic cells and mercury-dropping electrodes were shown and the apparatus, of recent introduction, in which the stepped chart is produced by a recording pen, was seen in action. In the earlier instruments, which are now obsolete, the record was produced photographically on light-sensitive paper which had of course to be developed and dried before it could be used. The time saving effected by the pen recorder will be obvious. An attachment designed for employment with the pen recording polarograph, and known as the Univector, was also shown in use. With this attachment an alternating voltage is superimposed on the continuous voltage and the resulting polarogram is of simpler form and up to 20 times as sensitive as that normally obtained. The record is not of step formation but in the form of a series of peaks the height of which above the base line is directly proportional to the concentration of the particular element. It is possible to detect many substances at concentrations as low as 0·1 mg. per litre and concentrations of 10 mg. per litre can be dealt with in ordinary routine work, as compared with the 100 mg. per litre concentration that is usual in step polarography. Although primarily designed for use with the pen-writing polarograph it can be employed with the photographic type.

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POWER REACTOR PROJECTS THROUGHOUT THE WORLD

Reprints of ENGINEERING Article

The demand for copies of the article "Power Reactor Projects throughout the World" (ENGINEERING, October 7), has been so large that a second reprint has been necessary. The article was written by Mr. G. W. K. Ford, of the Atomic Energy Research Establishment, Harwell, and is believed to be the most comprehensive analytical and comparative treatment so far published.

Copies are available at 2*s.* 6*d.* each post free from the Publisher, ENGINEERING, 35 & 36 Bedford-street, Strand, London, W.C.2. On orders of 12 or more the rate will be 1*s.* 6*d.*

CONTROLLING HYDRAULIC POWER

USE OF ACCUMULATORS IN HEAVY INDUSTRY

Hydraulic accumulators are of two basic types, weight-loaded and gas-loaded, the latter being capable of sub-division according to whether the gas and pressure liquid are in contact or separated. Further sub-division of the separated type is possible on the basis of how the separation is achieved. It is also possible for small accumulators to be spring-loaded; these possess some of the features of the gas-loaded type. These definitions were the basis of a paper entitled "Hydraulic Accumulators in Heavy Industry," delivered to the Institution of Mechanical Engineers on December 2, 1955, by Mr. J. G. Frith, M.I.Mech.E., assistant chief engineer in charge of hydraulic machinery and steel strip processing machinery, Davy and United Engineering Company, Limited. An abstract of the paper is given below.

One of the advantages of hydraulic power is that the pressure fluid can be stored to enable short periods of peak demand to be met from a supply source having a much smaller rate of delivery. In the early days of the hydraulic press it was realised that it was an advantage to use an accumulator with a single press or machine. When several presses or machines were being used it was uneconomic and often impracticable to fit one of the slow-running and cumbersome pumps of the time to every press, and an accumulator was essential. The position has been modified somewhat by the introduction of small high-speed pumps directly coupled to an electric motor, and many types of machine are now designed as self-contained units. Nevertheless, there are still many applications where an accumulator is either essential or of definite advantage.

As an example, a press of say 3,000 tons capacity, with a pressure stroke of 10 in., an operating-time cycle of 1 minute and a pressing speed of 2½ in. per second would require 1 h.p. per ton of press power; the pumping capacity would therefore have to be of 3,000 h.p. if the pumps were directly coupled to the press. The pumps would only be operating for 4 seconds in every minute, and the ratio of time on load to total time would be very low. If an accumulator were used, with a capacity equal to at least one full press stroke, the pumping time could be extended to, say, 40 seconds per minute, and the capacity of the pumps would only need to be equal to 300 h.p. In addition, the rate of draw-off from the accumulator could be varied as required.

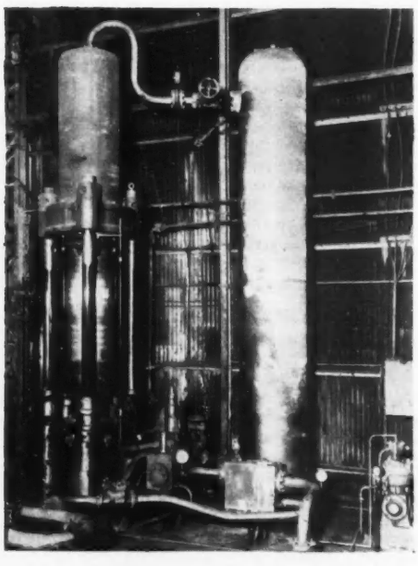

Fig. 1 A gas-loaded accumulator of the piston separated type can be controlled by tappets and switches in the same way as the weight-loaded type.

There are numerous other applications for hydraulic accumulators, including, for example, the supply of hydraulic fluid at a steady pressure for balancing moving parts of machinery. Where an interruption of the hydraulic supply may be dangerous, the accumulator provides a reserve of power to set the equipment to a safe position.

WEIGHT LOADING

The design of the weight-loaded accumulator has remained substantially unchanged for many years. It consists of a vertical single-acting ram and cylinder, one of these components being fixed to a foundation while the other has a crosshead on the upper end to which the loading weight is attached. Earlier designs had a fixed ram and a moving inverted cylinder, but later practice is to have a fixed cylinder and a moving ram. This design gives easier access to the gland for re-packing, and the men engaged on this work do not have to stand under the weighted portion, which makes for greater safety. The weighted portion is usually a steel tank filled with slag or other heavy material, but cast-iron weights, or, in the case of smaller sizes, concrete slabs, may be used.

Control of the pump or pumps is by means of tappets mounted on the moving part of the accumulator. These operate electric limit switches to start and stop the pumps if the installation works on an on-off basis, or else they control a by-pass valve if the pumps run continuously. A weight-loaded relief valve is fitted to avoid excess pressure, and this valve can be operated by a tappet or other means if, as a result of pump control gear failure, the accumulator continues to rise after reaching its normal top position.

Weight-loaded accumulators are comparatively simple, but they have certain disadvantages, particularly where large capacities are required. Among these are the height, and the amount of loading material required. The latter can be very considerable, as a ram 10 in. in diameter requires 78 tons of weights to give a pressure of 1 ton per square inch, and for the same pressure a ram 25 in. in diameter needs 490 tons. The large weight required has to be set in motion each time hydraulic fluid is drawn off and stopped again when the flow ceases. To minimise water hammer the falling speed must be kept as low as possible, thus limiting the rate at which liquid can be drawn off. Shocks from the driven machine are also transmitted back to the accumulator, where they are not easily absorbed owing to the inertia of the weight, and the combined effects of the two sources of shock can lead to heavy maintenance charges.

GAS LOADING

The gas-loaded accumulator uses a compressed gas as the loading medium, thus saving space and eliminating the inertia effects of the heavy moving mass. The gas also acts as an elastic medium, which absorbs shocks transmitted from the machines being operated. Expansion and contraction of the gas are accompanied by equivalent changes in pressure of both the gas and the liquid. This may be considered a disadvantage when compared with the more uniform pressure obtained from a weight-loaded accumulator, but the variation can be controlled by using a suitable ratio between the volumes of the gas and the usable liquid; it is normally confined to a figure of about 10 per cent. Another useful feature of the gas-loaded accumulator is the fact that the hydraulic pressure can be reduced by releasing some of the gas, which makes it possible to adjust the hydraulic pressure to suit the work thus saving pumping power.

A typical gas-loaded accumulator, of the separated type, is shown in Fig. 1. It is somewhat similar to the weight-loaded type, having a vertical hydraulic cylinder and ram. The cylinder is, however, machined on its outer surface, and acts as a ram in a fixed air vessel, which is connected by piping to one or more air bottles to give the required volume of compressed air. The total air capacity is governed by the permitted pressure-drop, which is usually between 8 and 12 per cent., but may be as much as 15 per cent. for economic reasons. An air compressor forms part of the equipment. It can be relatively small, as it is only used for the initial charging of the accumulator and for any subsequent topping-up or pressure-adjustment which may be necessary.

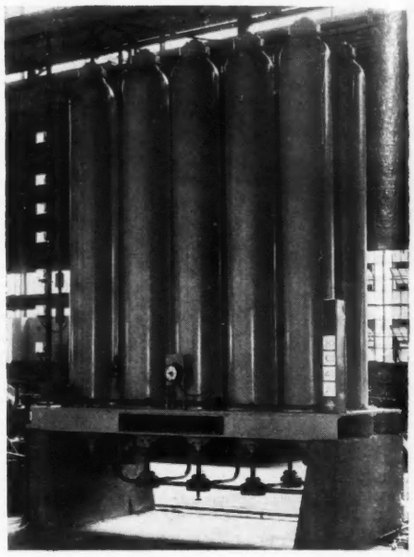

Fig. 2 A typical accumulator of the gas-loaded, non-separated type, has a steel cylinder for the liquid and gas, and one or more steel bottles for gas only, according to size.

Another type of gas-loaded accumulator in which the gas and liquid are separated is that which makes use of a bag or diaphragm as the separator. This type is made in a range of standard sizes and pressures, and two or more can be coupled together to give capacities beyond those in the standard range. Each unit consists of a seamless alloy steel shell. The bag, which is of synthetic material, is mounted inside, with an integrally-formed high-pressure gas valve secured through a hole in the top of the shell. A larger aperture in the base of the shell allows the bag to be drawn into position, and an oil-discharge plug is then fitted into the aperture. A spring-loaded poppet valve in the plug is used to maintain high volumetric efficiency and to prevent extrusion of the bag through the plug. Air can be bled from the system when necessary through an air valve in the side of the plug. The lower mouth of the shell is designed to spread at a pressure below the designed bursting pressure.

In use, the gas, which can be air or nitrogen, is contained inside the bag, and the hydraulic liquid occupies the space between the outside of the bag and the inside of the shell. The gas and liquid pressures are always equal and the bag floats in equilibrium. Control is by means of pressure switches. These accumulators can be used in pipe lines to smooth out pressure surges caused by pump pulsation, and also to absorb the shock in hydraulic mains caused by the rapid operation of valves.

NON-SEPARATED LOADING

It was thought at one time that if the gas and liquid were in direct contact with each other, absorption of gas by the liquid would cause a continuous loss of gas from the accumulator. In practice very little, if any, trouble is experienced from this cause, and many hydraulic accumulators are now in use where the gas and liquid are in direct contact.

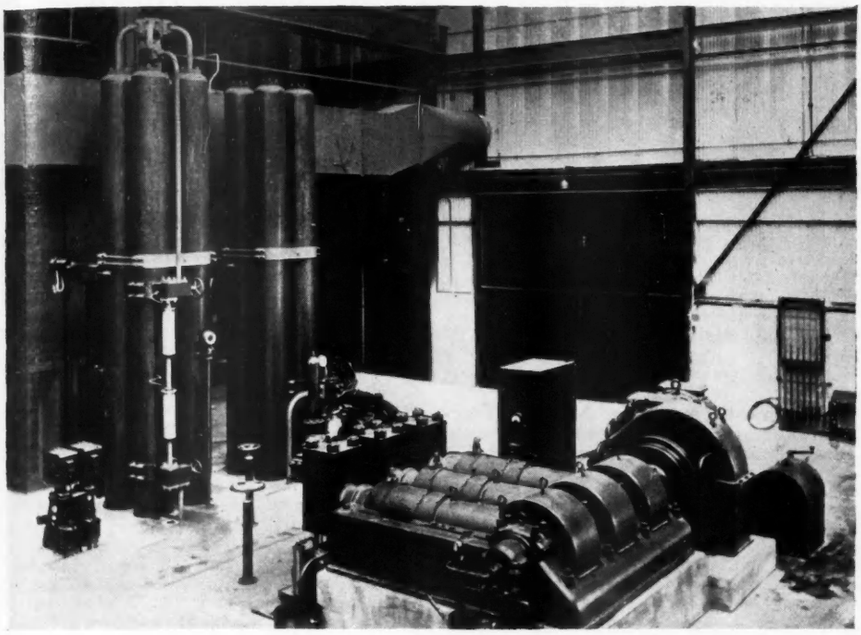

Fig. 3 Control of non-separated accumulators can be by one of several methods. In the one illustrated above induction coils and floats are used.

Accumulators of this type consist of one or more steel cylinders or bottles, forged for the higher pressures and fabricated for the lower. A small accumulator will have one bottle, which contains both the liquid and compressed gas, but larger sizes require additional bottles, which usually contain gas only. A multi-bottle unit is shown in Fig. 2. The gas is usually air when the hydraulic liquid is water, and an inert gas such as nitrogen when the liquid is oil. Isothermal conditions are generally assumed when calculating the relative volumes of gas and usable liquid. A reserve of liquid must be left in the accumulator at the low working level to allow time for the safety shut-down or automatic stop valve to operate, and also prevent a vortex being formed at the bottle outlet, which would allow gas to be drawn into the hydraulic system. The total volume of the accumulator bottles is found in practice to be 10½ or 11 times that of the usable liquid.

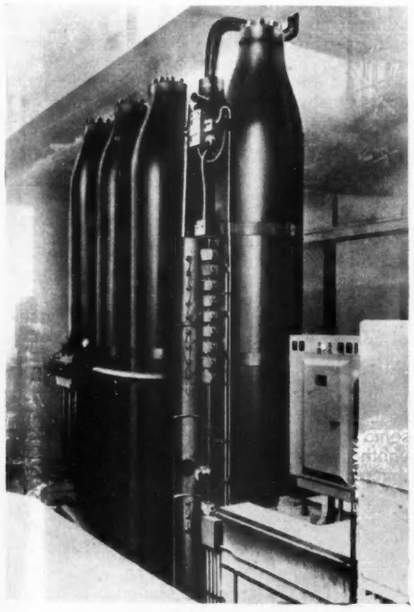

Fig. 4 An alternative control method is to have a series of electrodes which make a circuit when the water rises or falls to a particular level.

CONTROL GEAR

In the weight-loaded accumulator, and also in the gas-loaded type which has a ram to separate the gas and liquid, there are moving parts which can be used to actuate suitable valves for control purposes. In the non-separated accumulators the only movement is that of the liquid level, and the control is more difficult. It is inadvisable to control the accumulator by pressure only, as can be done in the bag separator type, as any fall in working pressure due to a gas leakage might cause the bottles to be flooded before the pressure necessary to actuate the controls had been reached.

The normal method is therefore based on liquid level, with a high pressure control as an over-riding safety feature. One type of control gear is based on magnetically-operated switches. This arrangement consists of a control tube mounted in parallel with the liquid bottle, the switches being fixed at appropriate points on the outside of this tube. The switches (which can be seen on the left of Fig. 2), actuate relays controlling the operation of the system as required. The control tube is non-magnetic, and is connected at the top and bottom to the liquid bottle so that the rise and fall of the liquid in the bottle are reproduced in the tube. Permanent magnets float in the liquid in the tube, and as they rise and fall they tilt magnets mounted in the switches, which are of the glass-tube mercury type.

Another type of control gear is the induction coil pattern. This control, which is shown in Fig. 3, also has a control tube and floats, the latter having steel cores. Induction coils are fitted round the outside of the control tube. The coils are part of a balanced bridge circuit, and a relay is connected across the bridge which does not normally carry current, but is energised only when the flow passes through the coil connected to the respective relay circuit. Both the magnetic and the induction coil control gear are so designed that in the event of current failure no liquid can be supplied by the pump or drawn from the accumulator.

The control gear shown in Fig. 4 has a control tube fitted with blocks at selected levels in which special electrodes are mounted. The system operates by making a contact between the electrode-tip and earth through the water; each electrode operates a relay through an electronic circuit, and so effects the control required.

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VALVE SPRING FAILURES

Methods of Improving Fatigue Endurance

Mr. J. H. Darley, F.R.I.C., F.I.M., of the Admiralty Engineering Laboratory, presented a paper, "Causes of Failure in Internal Combustion Engine Valve Springs" to the Diesel Engineers and Users Association on November 17. In it he discussed the manufacture of springs and the typical defects and failures encountered.

The greater part of the springs used in this country are made from wire cold drawn from steel rod. During the rolling of the rod, various defects can be caused such as surface decarburisation, the entrapping of scale and the formation of rolling seams, and it is important that these should be removed before drawing. Springs with wire diameters greater than 0·375 in. are often made from annealed wire and thermally hardened after coiling. Experience, however, has generally shown that springs more uniform in character can be obtained by coiling directly from the hard-drawn wire.

Helical compression springs using wire below about 0·375 in. in diameter can be quickly and conveniently formed on automatic machines. The wire is fed through pairs of rollers and guided round an arbor by deflecting tools, and then cut at the correct length. Precautions should be taken to avoid damaging the wire during coiling by score marks which can act as stress raisers. After coiling, springs made from hard-drawn wire are heated to about 400 deg. C. to relieve any stresses set up and the ends ground square. They are then compressed solid several times and given further heat treatment at 150 deg. C. to stabilise them. At this stage protective coatings of zinc or cadmium may be deposited if desired, and this should again be followed by further low-temperature heat treatment to avoid hydrogen embrittlement. Sprayed metal coatings of zinc or aluminium are also used.

The metallurgical factors which cause failure during service may be divided into three broad groups: (1) material faults affecting the wire as a whole; (2) material faults affecting the surface only; and (3) conditions which reduce the ability of the material to withstand cyclic stress. Of these, the first group covers non-metallic inclusions which may be formed during rolling and may lead to internal rupture after cold-drawing; and the second group includes surface discontinuities such as laps, scale rolled into the surface, oxide penetration and coiling marks, as well as surface decarburisation as a result of repeated heating. In contrast, the third group is concerned with the working conditions of the finished spring, and includes corrosive atmospheres, chafing and the like. Corrosion fatigue can be combated by protective coatings, but these must not affect spring performance. Tests carried out with various coatings have shown that some of them give a considerable increase in life—as much as 2½ times the basic value. Shot peening is another surface treatment which gives considerable improvement in the endurance limit; liquid honing or blasting also gives an improvement.

In general, for the manufacture of valve springs for internal combustion engines and the treatment of such springs to improve their resistance to normal and to corrosion fatigue, it is considered that the following points are of major importance: (1) use the best quality wire, preferably hard drawn; (2) coil with care to avoid damaging the wire; (3) shot peen under carefully-controlled conditions; and (4) coat the surface of the spring preferably with a non-metallic substance capable of resisting hot lubricating oil. Recent developments suggest that lacquers of epoxide resins show great promise for the last requirement.

The Iron and Steel Institute Autumn Meeting in London (continued from page 757)

EXAMINING THE INSIDE OF A FURNACE

B.I.S.R.A. SCANNING TELESCOPE

We continue our report of the annual autumn general meeting of the Iron and Steel Institute, held in London on November 16 and 17, by dealing with the first of two papers presented and discussed at the first session, on the morning of November 16 at the conclusion of the business items. The President, Sir Charles Bruce-Gardner, Bt., occupied the chair.

The paper was by Mr. Charles Burns, of the instruments section of the physics department of the British Iron and Steel Research Association, and was entitled "A Furnace Scanning Periscope." It dealt with work undertaken for the steelmaking division of the Association as part of an investigation into the temperature distribution on the open-hearth furnace roof.

INSTRUMENT CONSTRUCTION

The author stated that an earlier periscope used in the Flame-Radiation Research Committee's experimental furnace at Ymuiden, Holland, had been built by the British Coal Utilisation Research Association. Its field of view had been restricted, but subsequently an optical system had been conceived by the British Iron and Steel Research Association, suitable for fitting into a projecting water-cooled jacket, having a total field of view of 120 deg. This would include the whole of the furnace interior when inserted through a single aperture in the back or the front wall. The apparatus could be used either for photographing the furnace interior or for visual examination, and developments were still proceeding.

Both still and cinematograph photography had been extensively tried out, and some tests had also been made with a high-speed film camera. The instrument, the author concluded, offered the chance of performing investigations, hitherto difficult or impossible, with a minimum of interference with the furnace. The facilities it offered of an unlimited view from an effective position inside the furnace walls could almost be said to add a new technique to the study of open-hearth furnace problems.

After presenting his paper, Mr. Burns showed a film much of which was taken with the aid of the new periscope. This gave an excellent impression of the kind of views of the inside of a furnace in operation which it was possible to obtain with the aid of the new apparatus.

Mr. J. W. Till in opening the discussion, said that the film had not given the instrument all the credit that it deserved, since the view was much clearer than some of the film had shown. The periscope had been designed primarily for scanning the roof of an open-hearth furnace from a position through the back wall. The fact that it had been possible to use the instrument successfully for observation of the flame, both through the front wall and through the end wall, as well as for its original purpose, had definitely enhanced its value.

The experience with the instrument at John Summers and Sons, Limited, had been mainly from the end of the furnace. In this position observation of flame development and flame application to the charge could be undertaken readily. They had made several studies of these flames, both visually and with the aid of a cine-film, and the results, part of which had been seen in the film just shown, had been very encouraging. The differences observed, however, were not always very easy to interpret, but they were of the opinion that the periscope would provide a means for studying the effect upon the flame of slight adjustments in burner position and inclination and of atomising conditions.

During the last few years a considerable amount of work had been done on the examination of the flow pattern inside open-hearth furnaces by means of models. It was hoped that the periscope would provide a means for observing the results of the changes suggested by model work.

In certain periods in the course of a heat there was a very heavy carry-over of slag, particularly if hot metal were used. This carry-over caused rapid wear on the furnace ends. The periscope had been set up at the John Summers works in the end wall, in a position in which the dripping from the end wall passed across the field of view. They had tried to obtain a quantitative value of the amount of wear on the end wall by counting the drips per minute. The material that dripped down approximated to the composition of the slag, but it was reasonable to assume that the dripping was closely associated with the rate of wear. They had followed quite a number of casts through on lines such as this, and felt quite certain that the severity of the wear could be observed to increase with an increase in hot-metal percentage; it could be observed to increase with tar fuel compared with oil fuel, and it had also been seen that the rate of wear increased rapidly if the reversal sequence were prolonged. In consequence, they had instituted a shorter reversal time and had made it automatic. In this way, they had cut down the rate of wear on the furnace end quite markedly.

LINING BEHAVIOUR

The wear on the main roof had not been observed in this manner, mainly owing to the construction considerations, but it would seem reasonable to expect that if a hole were available in the back wall, the periscope could be directed on to a particular area of the roof, and the dripping observed, in cases where it was known that wear was localised.

All that steelmakers asked Mr. Burns to do at the present stage was to reduce the size of the instrument and the size of the hole through which it had to be inserted in the furnace to the minimum in order to make the instrument more readily handled and more readily portable.

Mr. C. Burns, in reply, said that while the periscope was being prepared for commercial production, a good deal of thought had been put into cutting down the size and weight without prejudicing its optical performance. It would be found that the production model, which would be seen before very long, was a considerable improvement over the prototype, from the point of view of handling.

Mr. J. Monaghan asked Mr. Burns whether it would be possible to cut down the size of the instrument, to make it slimmer, so that it could be put through the tuyere of a blast furnace.

Mr. C. Burns, in reply, said that it should be quite practicable, if a demand arose, to make a periscope that would go down the tuyere of a blast furnace. It would require a fresh instrument, but it should be possible. The periscope at present was 6 ft. long overall and about 4⅛ in. outside diameter. It was hoped to cut this down to about 4 in. The length was quite immaterial from the operator's point of view, because only a few inches of the periscope nose emerged from the refractory. In point of fact, there was usually a good margin, and the rise in temperature of the water employed during operation at the open-hearth furnace was only a matter of 10 deg. C. or so. The problem in a blast-furnace tuyere would be slightly different, because it was exposed throughout its length to a blast of hot air and, at its nose, to a radiation comparable in intensity with what obtained in the open hearth. To sum up, although he would not like to commit himself definitely, he would say that there would be a good chance of producing a workable instrument of this nature if a research demand arose for it.

PHOTOGRAPHIC RECORDS

Mr. F. H. Saniter said that they, at the research department of the United Steel Companies, had all been very much interested in the trials that had taken place with this periscope. They had applied the television camera to the apparatus and had been able to get some really quite presentable pictures—so much so that one could visualise that eventually one might, if one wanted, have a television screen in the melter's cabin. He would like to know whether it would be possible to get a differentiation in temperature which meant anything if colour photography were used with this apparatus.

Mr. C. Burns, in reply, said that theoretically, there appeared to be no difficulty in using colour photography for colour differentiation in the same way as a member of the National Physical Laboratory staff had already done, some years ago, in photographing molten-steel streams.

Mr. F. Steghart asked Mr. Burns whether it was possible to use this instrument literally indefinitely. It was clear that it might be of great interest for use in automatic control, and the question that arose was whether there was any difficulty resulting from the splashing of hot metal or the accumulation of dust.

Mr. C. Burns, in reply, said that this was a matter on which prolonged trials and work in collaboration with John Summers and Sons had yielded a good deal of information. The slag and steel varied greatly with the siting of the instrument in the furnace. The back wall was the worst position, because this was straight and flush, and the periscope was sticking right out into the stream going down the furnace. The prototype could withstand this for a period varying from a few minutes up to half an hour, depending on the quiescence or liveliness of the bath. The position through a charging door was a good deal better, because the charging door itself constituted a recess and stopped direct splashes to a certain extent from finding the periscope windows. The periscope windows themselves in the production model would probably be a good deal better protected than in the prototype. The end position beside the burner, which had been used so much at John Summers and Sons, was the best of all, and one could do practically anything with a periscope there. On one occasion the periscope had been used, off and on, for a matter of five months and when taken out it was only a little dirty, with a light sooty deposit on it.

MEASURING TEMPERATURES

The President, in concluding the discussion, said that even if coloured photographs were obtained by means of the periscope they would indicate the relative temperatures one against the other, but would not give the actual temperature. It might be possible to add a visual water-cooled pyrometer to the instrument.

Mr. C. Burns, in reply, said that the suggestion of adding a direct-reading pyrometer in parallel with the periscope was interesting and might possibly constitute an investigation in itself. It would correlate, even if only qualitatively, the heat distribution of the objects in view with some absolute value. At B.I.S.R.A., at present, another line was being investigated whereby a different periscope with a slightly different optical system permitted one to look directly at any portion of the field of view and feed directly into a photo-electric detector. This also would require calibration from an independent source looking through the periscope optical system. The periscope had obviously a very wide field of application, and no doubt, in the future, some of the more interesting and perhaps more difficult investigations would give useful results.

To be continued

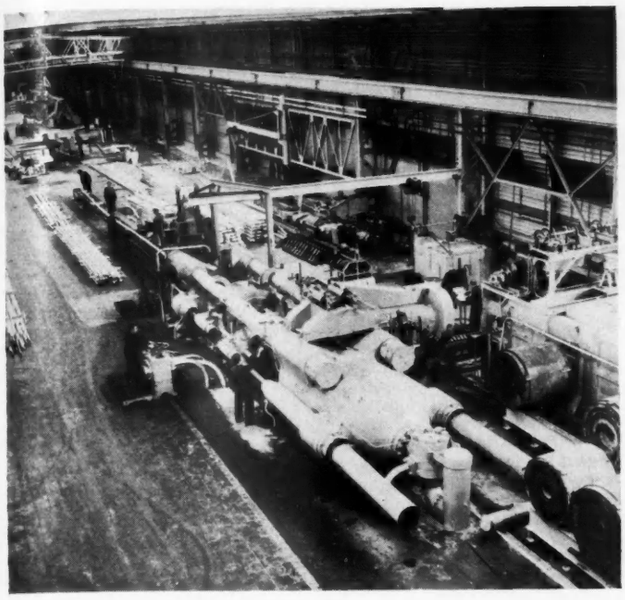


Fig. 1 Schloemann 5,000 ton aluminium extrusion press shown in position in the British Aluminium Company's new factory near Warrington. This press together with another of 3,500 tons capacity form the basis of an installation devoted almost entirely to the production of aluminium sections.

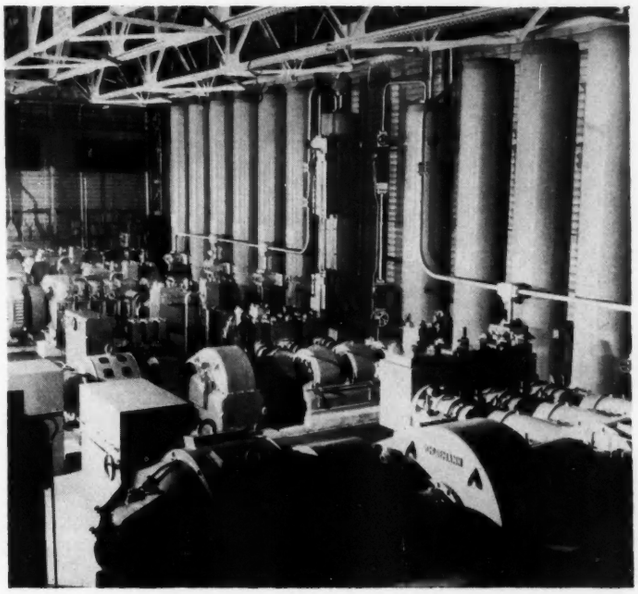


Fig. 2 Hydraulic pumps and air-loaded accumulators for extrusion plant. The system, which operates at 240 atmospheres, employs water as hydraulic medium. The accumulator section comprises 13 steel bottles, of which 11 are under air pressure and two are air-water bottles.

ALUMINIUM EXTRUSION FACTORY

PRODUCTION PLANT HOUSED IN THE PRODUCT

To increase its fabricating capacity and add to its range of products the British Aluminium Company has recently extended its premises by the completion at Latchford Locks, near Warrington, of a new extrusion plant. Roofed and walled in aluminium sheet, the building houses two large presses for the extrusion of aluminium-alloy sections, together with a variety of ancillary equipment for heat treatment, straightening and other purposes; it is thus an aluminium factory both by virtue of its product and by the nature of its construction. Among its interesting features are the hydraulic system which serves the presses; a number of automatic devices for handling the long extruded sections, including an unusual walking beam; a Birlec 60 ft. horizontal heat-treatment furnace; the use of electric cables incorporating aluminium cores and sheathing; and the " Dialindre " double-skinned construction of the factory walls. The British Aluminium Company, Limited, has its main offices at Norfolk House, St. James's-square, London, S.W.1.

TWO LARGE PIERCING PRESSES

Although the original Latchford Locks factory was formerly used mainly as a light-alloy scrap conversion plant for the production of foundry alloys, specialised casting equipment and techniques have been developed there for the manufacture of light-alloy rolling blocks and wirebars. It was therefore a short step to the production by semi-continuous casting procedures of the billets required for the new extrusion development.

The British Aluminium Company has been engaged in the production of aluminium and aluminium-alloy extrusions since 1911, and for many years this branch of the company's activities has been concentrated at their Warrington factory, which also includes a sheet and strip rolling mill. Until now, the extrusion presses used by the company have ranged in capacity from 600 tons to 2,500 tons, but developments in the aluminium-alloy structural, marine and transport fields have called for the use of heavier presses. These are required to meet the demand for larger sections in strong and medium-strength alloys to be supplied either in the " as extruded " condition or after heat treatment. Foreseeing these developments, the company some time ago acquired under reparations arrangements two piercing presses, one of 5,000 tons (Fig. 1) and the other of 3,500 tons capacity, made by Schloemann A.G., of Düsseldorf, together with heavy-section stretching plant. These two press units form the basis of the new extrusion scheme at Latchford.

DOUBLE-SKIN ALUMINIUM BUILDING

The site occupies 69·58 acres, of which the parent factory buildings occupy some four acres. Adequate space existed, therefore, on which to erect the new extrusion factory which, with its associated subsidiary buildings, occupies an area of 1·53 acres. The production plant is housed in a single bay of 106 ft. span, and 550 ft. in length, while a toolroom forms an annexe 40 ft. wide and 100 ft. long on the west side. The building consists of a steel structure enclosed in double-skinned corrugated aluminium sheeting, and extensive use has been made of distribution cabling in which both core and sheath is of aluminium. The building is lighted by 5 ft. fluorescent lamps at roof tie level and heated by radiant panels.

The supply of water presented something of a problem in that considerable quantities are necessary for section quenching at heat treatment, for which the town's water service was inadequate. Use of water from the adjacent Manchester Ship Canal for this purpose necessitated elaborate means of removing suspended-solids slimes, to avoid the risk of product staining. Water is, therefore, pumped from the canal to a break-pressure tank and thence through a self-cleaning Glenfield and Kennedy micro-strainer to a settling pond of 1,000 sq. ft. surface area. Secondary supply pumps draw from this clear-water source to provide the cooling-water service in the factory, which is maintained at a pressure of about 75 lb. per square inch. A separate booster pump is available to establish a high-pressure jet quench at each of the presses when required.

SEMI-CONTINUOUS CASTING

Metal is cast into extrusion billets from two fixed-hearth, oil-fired melting furnaces in the parent factory re-melt shop, the furnaces having bath capacities of 8 and 5 tons. These furnaces serve two screw-type semi-continuous casting machines having a range of electrical speed control from 0 to 15 in. per minute. Billets ranging in diameter from 10 in. to 16 in. are produced on these machines, which will ultimately handle cast stock up to 20 in. in diameter.

After extraction from the casting machines the billets are sawn to length on a Noble and Lund 60 in. " Flui-feed " saw which will accommodate the full range of billet sizes. For certain alloys and end products the billets are then scalped in a machine made by Wirth of Germany in which billets up to 37½ in. in length and 16½ in. in diameter can be machined to a depth of ⅜ in. in a single run at cutting speeds up to 2,920 ft. per minute with feed speeds ranging from 40 to 60 in. per minute. The machine is powered by a 100 h.p. two-speed motor. Built-in billet-handling facilities reduce idle time to a minimum and pneumatically operated centre grips ensure rapid location of the billet in the lathe.

A G.W.B. electric reheating furnace of chain-conveyor pattern is associated with each extrusion press. Rated at 715 kW, they are equipped with three-zone temperature control and forced air circulation with five circulating fans. The chamber width of 9 ft. accommodates two rows of billets on two sets of conveyer chains, which discharge the billets on to a traverse roller conveyer feeding billet handling gear for each press.

AIR-WATER HYDRAULIC SYSTEM

Both the 5,000 ton and the 3,500 ton presses are served from a common hydraulic installation operating at 240 atmospheres. The hydraulic medium is water with the addition of a corrosion inhibitor, and the accumulator system comprises a total of 13 steel bottles as seen in Fig. 2, of which 11 are under air pressure and two are air-water bottles. The length of each air bottle is approximately 21 ft. with an overall diameter of 3 ft. and a wall thickness of approximately 3 in. Each bottle weighs 13 tons and has a cubic capacity of 560 gallons. The hydraulic system is supplied from a total of five positive-displacement fixed-delivery three-throw pumps,

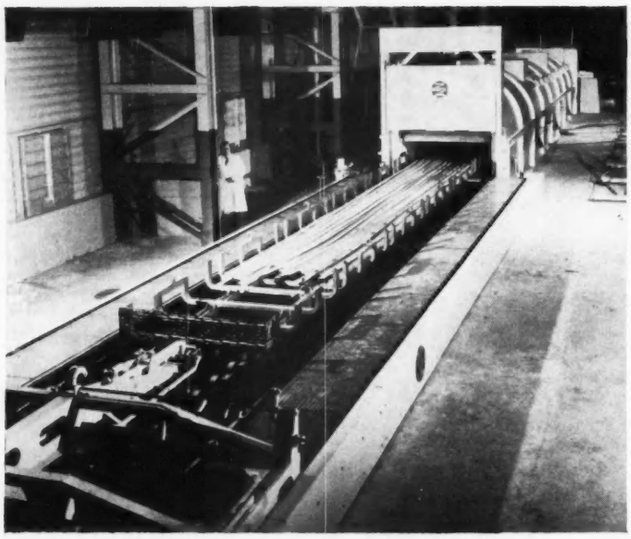


Fig. 3 Aluminium sections may leave the factory in the as-extruded condition or after heat treatment. The Birlec furnace employed for this purpose is designed for both precipitation and solution treatment, and has a heating chamber 60 ft. long.

having a total capacity of 450 gallons per minute and a total pump horse-power exceeding 2,000. Air compressor equipment is available for initially charging the air hydraulic system and for making good any air loss.

The presses themselves are served for container and die change purposes, and also for general maintenance, by a 25 ton E.O.T. crane made by Herbert Morris Limited, with a 5 ton auxiliary hoist.

The 5,000 ton extrusion press of Schloemann design and manufacture is a four-column unit having a total weight of some 350 tons, the main ram of which is 54 in. in diameter and has a maximum stroke of 100 in. Container heating is by induction, with the conductors forming an integral part of the container mass. Die sealing is by hydraulic rams operating under full system pressure, while the press is equipped with a run-out table 36 ft. long, beyond which a power-driven coiler for the drum coiling of extruded tube may be located. The press is capable of accepting billets running in size from 10 in. to 20 in. in diameter and in lengths up to 45 in., and billet discard from the die is effected by vertical hydraulic shear.

The 3,500 ton press incorporates a piercing ram of 500 tons thrust with the main ram capable of exerting 3,000 tons pressure. When the press is not engaged on piercing operations, however, the total pressure of 3,500 tons can be exerted. This press, which weighs approximately 250 tons, is of the three-column type and has a main ram diameter of 54¼ in., with maximum length of stroke 83 in. Die sealing takes place by wedge action, but container heating and discard removal arrangements are similar to those on the 5,000 ton press. The press is capable of accepting billets ranging from 8 in. to 12 in. in diameter. Both presses are equipped for automatic handling of billets and pressure plates; they are also furnished with extrusion speed indication and die-heating facilities mounted adjacent to the production plant.

AXIAL-FLOW HEAT-TREATMENT PLANT

The problem of transferring the long extruded sections from the presses to other parts of the shop has been solved by means of a novel handling device used in conjunction with a long open-sided cradle carried by an overhead crane. The handling device is a " walking beam," which consists of a number of padded supporting bars running sideways from the extrusion bench, between which and parallel to them are situated other moving bars. These are driven in unison with a rotary motion by means of an eccentric, and rise in a circular arc to lift the long extrusions and deposit them at each revolution a little further along the fixed bars. The extrusions are thus transported laterally along the beam with an " inching " motion until they lie immediately above the cradle, which has been lowered to accommodate them. The cradle is designed to lift through the fixed and moving bars so that the extruded sections are gathered as the load is taken.

The section heat-treatment furnace which is illustrated in Fig. 3, was made by Birlec, Limited. It is of the horizontal type rated at 500 kW, and is capable of accepting a maximum section length of 60 ft. Loaded skips are charged into and discharged from the furnace by means of electrical " go-getter " equipment which quickly and automatically locates the hot charge extracted from the furnace on to rails for rapid immersion in the quenching water. The overall length of the complete installation, including both furnace and quench tank, is approximately 160 ft.

Of a type exclusively developed for the solution and precipitation treatment of aluminium sections, the furnace consists basically of a heating chamber 60 ft. long divided longitudinally into two parts one above the other. Air circulates at a velocity of 80 ft. per second through a lower chamber, is deflected through 180 deg. by special vanes at the door end of the furnace and returns along the upper chamber. This unusually high air flow rate, which ensures temperature differences of only $\pm$ 2 deg. C. across the charge is achieved by a baffled twin-entry fan which is powered by an 80 h.p. motor and has 5 ft. diameter fans operating at 550 r.p.m.

The furnace, which is rated to produce 25 tons per week, is designed to handle aluminium sections varying from 2 in. by 2 in. angle up to 12 in. by 6 in. channel.

Two separate operations are carried out: solution treatment at 550 deg. C. followed by a precipitation treatment at 200 deg. C. For these operations the charge loads are of the order of 0·8 tons and 4·0 tons, respectively. Charges are loaded on to articulated steel skips 5 ft. wide by 1 ft. high by 60 ft. long. Heated by elements of sinuous formation arranged to give an electric loading of 500 kW, the furnace is lined with lightweight refractory backed by diatomaceous insulating bricks together with a special seal to ensure that no air channelling takes place.

The quench tank, situated immediately in front of the furnace, consists of a steel tank sunk below floor level measuring 63 ft. long by 7 ft. 3 in. wide. The steel skip, which runs on roller tracks in the furnace, mounts the quench platform and runs on a double row of idle rollers. Under a system of hydraulic cylinders this platform is rapidly lowered into the quenching medium. Running along the length of the quench tank, an electrically-operated bogie head serves for traversing the charge into the furnace and then extracting it when required.

STRETCHING AND STRAIGHTENING

The section stretching plant comprises five machines: a Fielding and Platt unit with a maximum pull of 30 tons designed to accept a section length of 80 ft.; two units made by Joshua Bigwood and Sons built to give maximum pulls of 100 and 150 tons and to accept section lengths of 50 ft. and 80 ft.; a Kieserling and Albrecht machine providing a 200 ton pull and accepting 60 ft. section lengths; and a 585 ton Schloemann machine capable of accepting lengths up to 47 ft. The two Bigwood plants and the Schloemann unit are supplied with hydraulic power from the central water system at 3,600 lb. per square inch, while the Fielding and Platt machine incorporates a self-contained oil pump operating at 2,240 lb. per square inch; the Kieserling and Albrecht machine is supplied by a self-contained oil pressure system at 1,760 lb. per square inch.

The 100 ton, 150 ton and 585 ton stretchers are each equipped with facilities for de-twisting sections under tension and, furthermore, the 585 ton unit, which can be seen in Fig. 4, has a potential design capacity of 700 tons when equipped with a self-contained hydraulic supply at 300 atmospheres. Provision has also been made in the foundations of this stretcher for later extension to cater for 75 ft. finished lengths of section.

In addition to section saws, the finishing equipment includes 30 and 40 h.p. multi-roll straightening machines, a Henry Berry 100 ton horizontal bending and straightening press, together with profile-correcting machines and other items. The finishing plant and warehouse are served by two two 7½ ton E.O.T. cranes 100 ft. in span supplied by S. H. Heywood and Company.

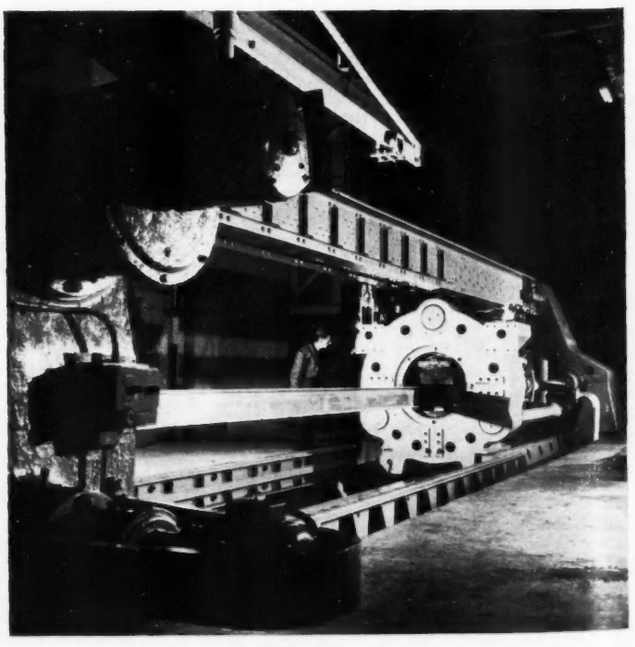


Fig. 4 For straightening the aluminium sections after extrusion or heat treatment five stretching machines have been installed, including the 585 ton Schloemann unit illustrated. It incorporates de-twisting heads.

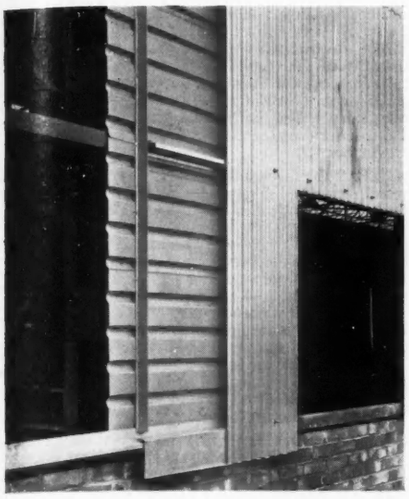


Fig. 5 " Dialindre " cladding construction of factory walls. Aluminium has been widely used in the new building, which is roofed in Anderson's aluminium " E " decking; aluminium has also been employed for the cores and sheathing of electric cables.

The Latchford extrusion plant as it exists at present is capable of producing a wide range of extruded sections, including all those covered by B.S.1161. Sections in the fully-heat-treated condition can be made up to 55 ft. finished length, while non-heat-treated sections up to a maximum of 75 ft. can be produced. The extrusion capacity of the Latchford factory will be complementary in type and size of product to that of the neighbouring Warrington Bank Quay Works. Products range from structural members for building construction to finned heat-exchanger tubes for atomic energy installations.

COMPOSITE ALUMINIUM DECKING

The main building, which is 550 ft. long, is of fairly conventional steel construction designed to carry one 25 ton and two 7½ ton cranes; the span between crane rails is 100 ft. with a height to truss tie level of 30 ft. The profile of the truss is of Mansard design and allows stretches of patent glazing on either side of the building above the eaves, together with a continuous lantern of patent glazing along the ridge for the full length of the building, giving a good distribution of light over the entire shop floor. Provision has been made for attaching, on 250 ft. of the west side, a structure of similar span, and the north gable can be removed to extend the length of the present building if necessary. Attached to the west side of the main building is a 40 ft. wide toolroom, 100 ft. long, which can be extended to 200 ft.

Ancillary buildings include a boiler house and a sub-station. The roof of the main building, which has a 5 deg. slope with purlins at 6 ft. 9 in. centres, is covered with Anderson's aluminium " E " decking comprising 19 s.w.g. corrugated aluminium decking (fabricated by the British Aluminium Company), ½ in. insulation board bonded in bitumen compound and covered with two layers of Rokbond bitumen roofing, continuously bonded in bitumen compound, and a surface dressing of bitumen finished with gravel.

TWO-SKIN WALL CLADDING

The walls are clad by the " Dialindre " method developed by Freeman, Morrison, Limited, which involves a double skin of corrugated aluminium sheeting spaced 2 in. apart by folded aluminium distance pieces. An example of this construction is shown in Fig. 5. The outer skin in this case is Rigidal 3 in. pitch corrugated sheet of 20 s.w.g. normally laid, and the inner skin Rigidal, Mansard sheet of 24 s.w.g. with the corrugations running horizontally. This inner skin has been Alocrom treated to give a pleasant appearance. The roof and walls of the toolroom are similarly treated, but here the inner skin in addition to being Alocromed is also stucco embossed.

The " U " value of " Dialindre " double-skinned sheeting is of the order of 0·27 and although it has not been possible to ascertain the heat losses during the winter months, tests were carried out during the past summer which showed that on an average the temperature inside the building was 10 deg. F. lower than in an adjacent building covered with a single skin of corrugated aluminium sheeting. The building is ventilated naturally with roof ventilators and inlet louvres low down in the side sheeting.

Heating is by high-pressure hot water supplied by a Danks (Netherton) boiler which is Clyde Automatic oil fired and has a capacity of 5,800,000 British thermal units per hour and a working pressure of 120 lb. per square inch. 88 radiant panels, each 8 ft. by 4 ft. fixed adjacent to the walls below crane gantry level and five unit heaters at truss tie level maintain a thermostatically controlled internal temperature of 60 deg. F. with 1½ air changes per hour. The boiler has an excess capacity of 28 per cent., but provision has been made in the boiler house for an additional boiler to cater for future extensions to the building.

Prodorite " Ferrogran " tiles were laid on the main passageways and areas of the floor which are subject to heavy wheel traffic, and the remainder of the floor is finished in granolithic. Covers for ducts, pits around parts of the plant, and the treads of access ladders to the cranes are made of aluminium P-G-P heavy pattern treadplate, and aluminium tubing was used for the handrailing around plant enclosures. Additional office accommodation was obtained by attaching to the general offices of the adjacent parent factory a single-storey Hawksley prefabricated aluminium building which provided a rapidly-erected permanent structure.

ALUMINIUM IN ELECTRIC CABLES

Although there is nothing novel in the use of aluminium in electric cables for both conductors and sheaths, the Latchford factory is believed to be the first large-scale installation in this country in which aluminium has replaced the conventional copper and lead on such a scale. Except for the largest power cables, aluminium has been used throughout the installation as conductor material both in rubber-insulated wiring cables and in paper-insulated cables of all types, both medium and high tension. Where sheathed cables are used the sheaths also are of aluminium, with the exception of some large 1·0 square inch cables feeding the main mediu m-voltage sub-station switchboard from the transformers.

The installation contains approximately 3,000 yards of all-aluminium paper-insulated cable to B.S. 480, and 14,300 yards of aluminium conductor V.I.R. or P.V.C. insulated cable to B.S. 7 or B.S. 2004, of which 4,500 yards are aluminium sheathed, the remainder being taped and braided. In addition to the foregoing, some 1,000 yards of three-core 0·4 to 0·6 square inch paper-insulated aluminium sheathed cable having copper conductors has been installed.

Experience on the Latchford scheme has shown that an all-aluminium cable scheme, including both feeder systems and factory or building wiring, offers a significant saving in cost as against a cable installation embodying traditional materials. It has also been found that normal installation procedure can be employed, and that the lightness of aluminium cables provides a considerable advantage in handling.

SIX ACRES WITH ALUMINIUM ROOF

The main contractor for the erection of the factory was Sir Alfred McAlpine and Son, Limited, who were assisted by: for concrete piling, West's Piling and Construction Company; for structural steelwork, Redpath, Brown and Company; for roof decking, D. Anderson and Son, Limited; for aluminium cladding, Freeman, Morrison, Limited; for patent glazing, Haywards Limited; for heating, Matthew Hall Limited; and for the aluminium folding shutter doors, the Bolton Gate Company. The power and lighting installations was carried out by Troughton and Young, Limited, with cables supplied by British Insulated Callender's Cables Limited, and all jointing on paper-insulated power cabling was carried out by British Insulated Callender's Construction Company.

It is also of interest that another factory extension making wide use of aluminium in its construction is situated in the Warrington area. This building, which is the second stage of a scheme announced by Thames Board Mills, Limited, last year, occupies 6·2 acres. Aluminium in the form of Anderson decking is used for roofing.

* * *

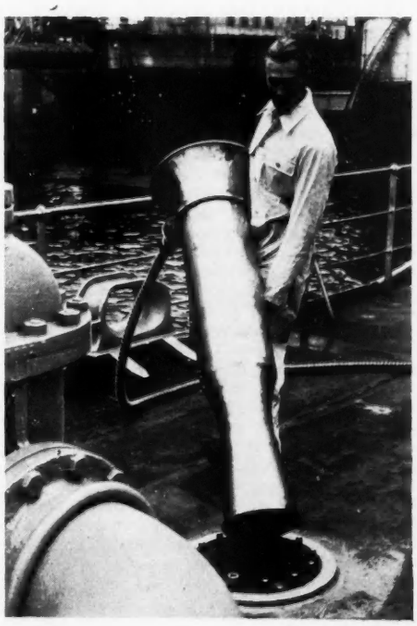
DISPERSION OF DANGEROUS GASES

Purging Oil Tankers

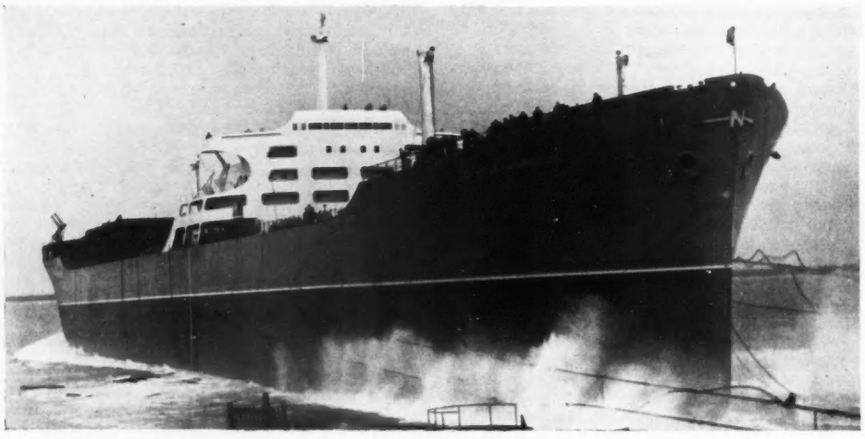
A ventilator to remove dangerous gases left in an oil tanker's cargo tanks when oil or petroleum has been discharged has been produced by the Swedish firm A.B. Götaverken, Göteborg, 8. The ventilator, shown in the accompanying illustration, consists of a metal trunk about 5 ft. long, weighing 77 lb. This trunk has a nozzle at its upper end which is connected to the ship's steam line; compressed air, if available, can be used instead of steam.

The ventilator is inserted in the tank cleaning hatch in the deck, as the illustration shows, and the steam is turned on. It passes through the nozzle and draws with it fresh air; the jet of mixed steam and air has a velocity of about 200 ft. per second at the ventilator mouth. The jet passes down to the bottom of the tank where it divides and swirls, finally travelling up the sides to the open hatches bringing with it the gases that were in the tank.

The amount of steam injected per hour is about 1,300 lb., and the accompanying air amounts to about 420,000 cub. ft. This volume of air and steam can clear the gases from every part of the tank, and the system is claimed to free tanks from gas more quickly than previously used systems.



This ventilator for clearing dangerous gases from the cargo tanks of oil tankers, weighs 77 lb., and is connected to a steam or compressed air supply. A mixture of air and steam is introduced into the tank through the cleaning hatch, and the mixture comes out through the main hatches bringing the gases with it.



The turbines of the single screw tanker "Spyros Niarchos" develop 18,000 s.h.p. at 101·4 r.p.m. Her cargo capacity is 47,750 tons deadweight.

THE WORLD'S LARGEST OIL TANKER

"Spyros Niarchos" Launched at Barrow

The oil tanker Spyros Niarchos, which was launched on Friday, December 2, from the Barrow shipyard of Vickers-Armstrongs (Shipbuilders) Limited, for the Neptune Tanker Corporation, one of the companies in the group controlled by Mr. Stavros S. Niarchos, is a vessel of multiple distinctions. Her designed deadweight cargo-carrying capacity of 47,750 tons makes her the largest tanker in the world; her launching brings to a total of 1,000,000 gross tons the post-war output of the Vickers-Armstrongs shipyards; she is the largest merchant ship built in the United Kingdom since the war; and her shaft horse-power of 18,000 will be the greatest ever employed in a single-screw ship. She marks also a domestic change in the Vickers-Armstrongs organisation, as she is the first ship to be put into the water by Vickers-Armstrongs (Shipbuilders) Limited, the separate company formed by Vickers-Armstrongs Limited to operate their shipbuilding activities, which came into being on July 1, 1955.

The vessel was named and launched by Lady Weeks, whose husband, Lieutenant-General Sir Ronald Weeks, K.C.B., C.B.E., D.S.O., is the chairman of Vickers Limited, after a short religious service conducted by the Rev. John Mills, vicar of St. John's Church, Barrow.

The Spyros Niarchos has been built under the survey of Lloyd's Register of Shipping to receive the Society's highest classification as well as that of the American Bureau of Shipping, and has the following dimensions: length overall, 757 ft. and between perpendiculars, 725 ft.; breadth moulded 97 ft. 2 in.; depth moulded, 52 ft.; maximum draught, 37 ft. 9 in. Except at the ends, the hull is longitudinally framed, with two longitudinal bulkheads throughout the cargo space. It is all welded with the exception of two riveted seams on the bottom shell, the top and bottom seams of the bilge strake and the lower edge of the sheer strake, the stringer angle, and two seams on the upper deck. There are 33 cargo tanks, horizontally stiffened with deep transverse and longitudinal webs, and a small hold forward for dry cargo. Oil fuel is carried forward and aft in tanks separated from the cargo tanks by cofferdams. For handling the cargo there are four Drysdale turbine-driven horizontal centrifugal pumps, each with a capacity of 1,000 tons an hour, and three Carruthers steam-driven vertical stripping pumps, each of 150 tons an hour capacity. The cargo piping consists of four lines of 14 in. outside diameter, in addition to two 10 in. direct filling connections and a 6 in. ring-main stripping line.

The propelling machinery consists of a set of geared turbines of Parnetrada design, intended to give 18,000 shaft horse-power at 101·4 r.p.m. and a maximum output of 20,000 shaft horse-power at 105 r.p.m. The sea speed, at the load draught of 36 ft., is 17 knots. The high-pressure ahead turbine is of the impulse type and the low-pressure ahead turbine of the combined impulse-reaction double-flow type. Separate high-pressure and low-pressure astern turbines are fitted, the high-pressure astern rotor being contained in an entirely separate casing at the forward end of the high-pressure ahead turbine casing, and the low-pressure astern rotor in a separate casing incorporated in the low-pressure ahead casing. The two turbines drive, through double-reduction articulated gearing with forged nickel-steel pinions and built-up gearwheels, a five-bladed solid "Novoston" propeller, made by J. Stone and Company (Deptford) Limited. The shafting is of mild steel and is solid, the intermediate shaft being 21⅞ in. in diameter and the propeller shaft 25⅝ in. Steam will be supplied by three Foster-Wheeler "D" type water-tube boilers with cast-iron gilled economisers, at a pressure of 600 lb. per square inch and a temperature at the superheater outlet of 860 deg. F.

The accommodation for the captain and the deck officers, and the owner's apartments, are arranged in the bridge house, and for the engineers and the crew, in the poop. The navigational equipment is of the most modern type and includes radar, a gyro-compass and automatic pilot, echo sounders, direction finder, etc. The steering gear is of the electro-hydraulic type, with telemotor control from the bridge and mechanical control from the after steering position. The deck auxiliaries are steam driven. For the supply of electric power there are two turbo-alternators of 850 kW capacity, generating three-phase current at 450 volts, and a Diesel-driven alternator of 150 kW output for emergency use. Provision is also made for connecting a shore supply to the main switchboard.

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LAUNCHES AND TRIAL TRIPS

M.S. "Pearl Stone."—Single-screw cargo vessel, built by William Gray & Co., Ltd., West Hartlepool, for Mr. N. G. Livanos, Piræus, Greece. First of two sister ships for this owner. Main dimensions: 440 ft. between perpendiculars by 60 ft. by 38 ft. 9 in.; deadweight capacity, about 11,250 tons on a draught of 28 ft. 3 in. Kincaid-B and W. six-cylinder Diesel engine, equipped for burning heavy oil, constructed by John G. Kincaid & Co., Ltd., Greenock. Speed, 13 knots. Launch, October 31.

M.S. "Crystal Gem."—Single-screw cargo vessel, built by Hawthorn Leslie (Shipbuilders) Ltd., Hebburn-on-Tyne, County Durham, for the Sugar Line Ltd. (Managers: Athel Line Ltd.), London, W.1. Main dimensions: 430 ft. between perpendiculars by 61 ft. by 37 ft. 3 in. to upper deck; gross tonnage, 8,700; deadweight capacity, about 9,750 tons on a draught of 24 ft. 6 in. Hawthorn-Doxford four-cylinder opposed-piston oil engine, developing 3,300 b.h.p. at 108 r.p.m. in service, constructed by Hawthorn Leslie (Engineers), Ltd., Newcastle-upon-Tyne. Service speed, about 12 knots. Launch, November 1.

M.S. "Dona Ourania."—Single-screw dry cargo vessel, built and engined by William Doxford and Sons, Ltd., Sunderland, for the Compania Panamena Europea Navegacion Limitada, Panama. (Agents: Chandris (England) Ltd., London, E.C.3). First of two sister ships for these owners. Main dimensions: 450 ft. between perpendiculars by 62 ft. by 39 ft. 6 in. to upper deck. As open-shelter-deck ships, these vessels have a deadweight capacity of about 10,880 tons on a draught of 26 ft. 8¾ in., but when in use with closed shelter decks they have a deadweight of about 12,660 tons on a draught of 29 ft. 4 in. Doxford four-cylinder oil engine of 4,800 b.h.p., to give a speed of 13¾ knots at 112 r.p.m. in fair weather. Launch, November 2.

M.S. "Border Sentinel."—Single-screw oil tanker, built and engined by Swan, Hunter, and Wigham Richardson, Ltd., Newcastle-upon-Tyne, for the Lowland Tanker Co., Ltd., London (Managers: Common Brothers, Ltd., Newcastle-upon-Tyne). Main dimensions: 515 ft. between perpendiculars by 69 ft. 6 in. by 37 ft. 6 in.; deadweight capacity, 16,000 tons on a draught of about 30 ft. Swan Hunter-Doxford six-cylinder opposed-piston oil engine, developing 6,400 b.h.p. at 115 r.p.m. in service. Engine arranged to burn boiler fuel. Speed on trials exceeded 14¾ knots. Trial trip, November 3.

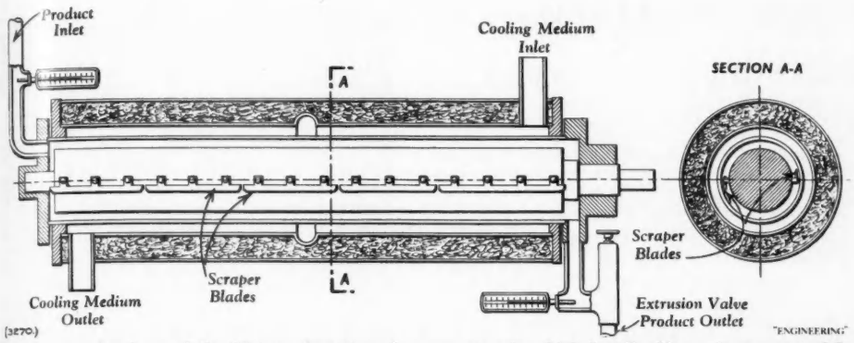
M.S. "Ferncliff."—Single-screw cargo vessel, with accommodation for twelve passengers, built and engined by Eriksbergs Mek. Verkstads Aktiebolag, Gothenburg, Sweden, for Fearnley and Eger, Oslo, Norway. Second of two sister ships. Main dimensions: 450 ft. between perpendiculars by 64 ft. by 41 ft. to shelter deck; deadweight capacity, 9,900 tons on a draught of 28 ft. 1 in.; total refrigerated-cargo capacity, about 27,500 cub. ft. There are also tanks for carrying 1,600 tons of vegetable oil and latex. Eriksbergs-B. and W. eight-cylinder single-acting two-stroke Diesel engine, developing 10,000 b.h.p. and arranged for burning heavy oil. Service speed, 17¾ knots. Delivered, November 8.

M.S. "Kristin Bakke."—Single-screw cargo vessel, with accommodation for twelve passengers, built and engined by the Götaverken Shipyard, Gothenburg, Sweden, for Hvalfangst-A/S Suderøy (one of the Knut Knutsen O.A.S. group of companies), Haugesund, Norway. Main dimensions: 507 ft. overall by 63 ft. 6 in. by 41 ft. 6 in. to shelter deck; deadweight capacity, 10,460 tons on a draught of 28 ft. 7 in. Götaverken nine-cylinder single-acting two-stroke Diesel engine, developing 8,200 b.h.p. at 112 r.p.m. Speed, 17 knots fully loaded. Delivered, November 10.

M.S. "La Orilla."—Single-screw cargo vessel, built by Bartram and Sons, Ltd., Sunderland, for Buries Markes, Ltd., London, E.C.3. Main dimensions: 445 ft. between perpendiculars by 62 ft. by 40 ft. 2 in. to shelter deck; deadweight capacity, about 10,850 tons on a draught of 26 ft. 11¾ in. Kincaid-Harland and Wolff-Burmeister and Wain single-acting two-stroke opposed-piston Diesel engine, constructed by John G. Kincaid & Co., Ltd., Greenock. Engine developing 4,400 b.h.p. at 115 r.p.m. in service and designed to operate on heavy oil. Trial trip, November 14.

M.S. "Stamos."—Single-screw cargo vessel, built by Short Brothers Ltd., Sunderland, for the Compania Farallon de Navegacion S.A., Panama (Agents: Fafalios, Ltd., London, E.C.3). Main dimensions: 450 ft. between perpendiculars by 61 ft. by 39 ft. 6 in. to shelter deck; deadweight capacity, about 10,700 tons on a mean summer draught of 27 ft. with open shelter deck, and about 11,670 tons on a draught of 28 ft. 6 in. with shelter deck closed. Kincaid-Harland and Wolff-Burmeister and Wain seven-cylinder single-acting two-stroke Diesel engine developing 5,000 b.h.p. at 110 r.p.m. in service, constructed by John G. Kincaid & Co., Ltd., Greenock. Engine arranged for burning heavy oil. Launch, November 14.

M.S. "Southern Prince."—Single-screw cargo vessel, built and engined by Harland and Wolff, Ltd., Govan, Glasgow, for the Prince Line, Ltd., London, E.C.3. Sister ship of the Western Prince. Main dimensions: 435 ft. between perpendiculars by 61 ft. by 38 ft. 6 in. to shelter deck; deadweight capacity, about 10,000 tons on a draught of 27 ft. 6 in.; gross tonnage, about 7,900. Harland-B. and W. five-cylinder single-acting two-stroke opposed-piston oil engine. Launch, November 16.



Diagrammatic views of the Votator heat-transfer apparatus in which hot liquid or viscous materials are forced through the narrow annular passage between a rotating shaft fitted with scraper blades and a heat-transfer tube. The scraper blades constantly expose a clean heat-transfer surface to the incoming material.

CONTINUOUS HEAT-TRANSFER APPARATUS

Laboratory to Investigate New Applications

For a number of years A. Johnson and Company (London), Limited, Africa House, Kingsway, London, W.C.2, have been licensed by the Girdler Company, of Louisville, Kentucky, U.S.A., to manufacture the Votator apparatus in Great Britain for sale to most countries outside the dollar area.

The Votator apparatus is in effect a continuous heat exchanger and has been used hitherto mainly in the food industry for the processing of such materials as margarine, lard, peanut butter and gelatine. It is stated that at least 80 per cent. of the margarine produced in Great Britain and in the United States is processed in Votator apparatus. This, it is claimed, provides margarine of uniform texture, consistency and weight and the process is continuous from the emulsion stage to the finished and packaged product.

The apparatus is shown diagrammatically in the accompanying illustration. It consists essentially of a heat-transfer tube, often of chromium-plated carbon steel, outside which a cooling medium, usually liquid ammonia, circulates. Rotating inside the tube is a " Mutator " shaft fitted with two rows of hardened stainless-steel scraper blades. The hot product which is being processed is forced by a pump through the annular passage between the shaft and the heat-transfer tube and it is deposited on the cool surface of the latter as a film. The revolving scraper blades, which are thrown outwards against the heat-transfer tube by centrifugal force, constantly expose a clean heat-transfer surface to the incoming material. This is cooled rapidly as it moves continuously through the tube to the outlet and is finally " extruded " or otherwise produced in the desired form.

With the object of widening the application of the apparatus, particularly in the chemical industry, a technical service department was formed by A. Johnson and Company this spring for the purpose of demonstrating established processes to new clients, developing new applications, investigating problems arising from new installations and engaging in fundamental research. To implement this programme a pilot-plant laboratory has been equipped to enable a wide variety of problems to be investigated. This laboratory, which is at the firm's works in Dukes-road, Western-avenue, London, W.3, was opened recently by the chairman of the company, Sir John Dodd, M.A., M.I.Mech.E.

As space is limited the laboratory occupies a relatively small area but emphasis is placed on the flexibility of the equipment and on the fact that the various units can be assembled quickly and accurately so that the best use is made of the space and equipment. Steam at 100 lb. per square inch pressure, hot water, primary refrigeration and compressed-air services are available and it is intended to extend these to include secondary refrigerating and other heat-transfer media. In addition to work on various foodstuffs, investigations on the processing of synthetic resins, greases and starches will be undertaken as well as the cooling, heating or crystallisation of chemicals. Mixing operations requiring aeration, emulsification or blending will be conducted and it is pointed out that any continuous or semi-continuous process involving the heating or cooling of a viscous or liquid material can be carried out.

It is stated that units are now available for use with such heat-transfer media as water, ammonia, brine, propane, ethylene, Freon, Dowtherm and steam. Consequently products can be quickly cooled or heated to temperatures lower than — 100 deg. F., or higher than 600 deg. F. Depending upon the materials processed, the overall heat-transfer coefficients obtained in the apparatus usually lie between 200 and 500 B.Th.U. per hour, per square foot, and per deg. F. Units are available having heat-transfer areas of from 0·7 sq. ft. to 60 sq. ft., while the capacities of single units range from less than 100 lb. of product an hour to 30,000 lb. an hour. The metals of construction may be carbon, nickel or stainless steels, or special alloys as required by the nature of the materials processed.

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MOTOR GRADER OPERATION EXTENDED

Attachment for Loading Spoil

The conversion of a standard motor grader into a high-capacity earth-moving machine able to trim a formation and load away the spoil into dumpers or lorries has been accomplished by the addition of an elevating attachment to their " Super 12 " by Blaw Knox, Limited, 90-94 Brompton-road, London, S.W.3. The modified machine, illustrated below, is able to load away at the rate of 750 cub. yards per hour or cast spoil at something approaching double that figure.

The elevating attachment comprises a conveyor with a 42 in. wide continuous belt driven from the motor crankshaft and running over roller idlers spaced 1 ft. apart. A 30 in. diameter plough disc, made of heat-treated carbon-manganese steel, feeds the spoil on to the belt conveyor. The basic length of the conveyor is 15 ft. but standard extension pieces of 3, 5 and 10 ft. enable conveyor lengths of 18, 20, 23 (one 5 ft. and one 3 ft. extension on to the basic 15 ft.) and 25 ft. to be obtained. With the 25 ft. length a counterbalance is required on the plough beam. As may be seen from the illustration, the discharge height can be altered by raising or lowering the boom by use of the power-controlled cables. All the controls are located in the cab.

The new attachment and the grader itself are described in an illustrated leaflet (publication No. 228) which has been recently published by the makers; copies of the leaflet are available on request from the address given above.

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MOBILE EXCAVATORS

Lorry-Mounted Vehicles for Oil Fields

To provide the mobility that is desirable for oilfield operation, two crane excavators recently supplied to the British Malayan Petroleum Company, Limited (a Shell associate) have been built up by mounting a 19-RB superstructure on a Scammell Constructor 6 by 6 chassis. Using suitable equipment, the machines can operate as mobile cranes, as grabs, or as dragline excavators. They will be used in oilfields of Borneo.

The Ruston Bucyrus 19-RB has a boom 35 ft. long, made up of sections of 15 and 20 ft. For the crane, a 5 ton single-sheave block will be used; for the grab, a 14 to 17 cub. ft. clamshell bucket; and for the dragline, a 21 cub. ft. bucket. All of these can be used with the 35 ft. boom. A box-girder boom is also available for operating a 5/8 cub. yd. excavator bucket as a dipper or skimmer, which is the standard type employed on the 19-RB crawler-mounted machine.

The Constructor is driven by a Rolls-Royce C6NFL 6 cylinder 12/17 litre engine, developing 160 h.p. at 1,800 r.p.m. A high and low range of gears together provide 12 forward and two reverse ratios. As the back-axle ratio is 10·25 to 1 a large traction potential is available. The superstructure is carried on a cast-steel base similar to that used on the crawler-mounted machines, including a double-flange path for the three hook-type conical swing rollers which are used in place of a centre post. Outrigger beams have been fitted to the chassis, both before and behind the turntable.

The BK " Super 12 " motor grader operating with a 25 ft. loading attachment. Loose spoil can be cut and lifted into dumpers or lorries at rates up to 750 cub. yd. per hour.

POWER FOR THE FUTURE

FIRST MEETING OF BRITISH NUCLEAR ENERGY CONFERENCE

The interest of British engineers in the development of nuclear power was amply illustrated by the success of the inaugural meeting of the British Nuclear Energy Conference. At the meeting, which was held at the Institution of Civil Engineers, London, on November 30, Sir Christopher Hinton, Managing Director of the Industrial Group of the United Kingdom Atomic Energy Authority, and Chairman of the Conference, said that in ten years nuclear engineering had so developed that it was now an important industry in its own right and by 1975 would involve business in the home market amounting to some £300 million a year. Nuclear energy should not be regarded as a completely new technology, but rather as an extension of existing technologies. Indeed, we ought to attribute our present satisfactory position in this field not to our ability to evolve technologies which were completely new or revolutionary, but rather to the ability which had been shown in developing existing techniques to problems which were completely new.

The Conference was formed jointly by the Institutions of Civil, Mechanical, Electrical and Chemical Engineers and the Institute of Physics, and is a collaborating and co-ordinating rather than a controlling body. The main objects of the Conference are to assist in obtaining papers on subjects related to nuclear energy; to arrange for the printing and publishing of these papers in the *Journal* of the B.N.E.C., the first issue of which will appear in January, 1956; and to promote meetings, symposia or conferences on a national or an international basis for the discussion of nuclear energy problems.

Four lectures were delivered at the meeting: the first by Sir John Cockcroft,* dealt with the work of the U.K.A.E.A. and the planning of Stage 2 and Stage 3 reactors; the second, by Mr. V. A. Pask,† and Mr. J. C. Duckworth, discussed the part to be played in United Kingdom power development by nuclear energy; the third, by Dr. A. S. McLean‡ and Dr. W. G. Marley, covered health and safety; while the last paper, by Mr. H. J. Grout,§ outlined the importance of research reactors in nuclear power development. Summaries of papers are given in this article. The attention of readers is drawn to previous articles in ENGINEERING on the subject of nuclear power: in particular, those in the issues of October 7 (page 490) and November 11 (page 652); references to further articles are given in the text of these two.

* Director of the Atomic Energy Research Establishment, Harwell.

† Chief Engineer, Operations Headquarters of the Central Electricity Authority; Mr. Duckworth is a nuclear power engineer of the same Headquarters.

‡ Group Medical Officer, Industrial Group Headquarters, Risley; Dr. Marley is Head of Health Physics Division, A.E.R.E., Harwell.

§ Head of Reactor Engineering Division, A.E.R.E., Harwell.

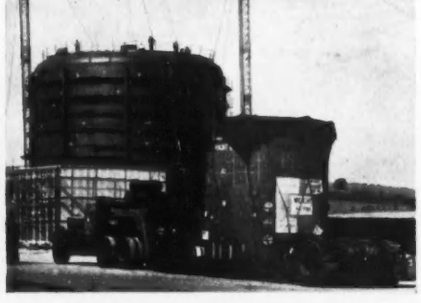

Fig. 2 Container of the high-flux heavy-water research reactor DIDO arriving on site; the reactor building can be seen in the background. (A.E.R.E. photograph).

REACTORS FOR STAGES 2 AND 3

In his paper, "The United Kingdom Atomic Energy Authority and Its Functions," Sir John Cockcroft said that the nuclear power programme of the future required the development of new types of power station as successors to the gas-cooled graphite-moderated stations which would be constructed by industry in successively improved marks. The Research and Industrial Groups of the U.K.A.E.A. were together exploring the different kinds of station offering prospects for the future and were carrying out design studies on the most promising types. During the last year, for example, a design study on the pressurised-water reactor had been carried out in collaboration with industry and the C.E.A. The comparative merits of this and other possible Stage-2 reactors were now being assessed. At the same time, longer range work was being carried out on still more advanced reactors such as the homogeneous reactor and the fast reactor. These together with zero-energy reactor physics studies would be followed by construction of an experimental reactor.

Each new reactor required the evolution of special technologies, such as the development of appropriate fuel elements and associated chemical-processing facilities for spent fuel elements. This development made necessary an intensive testing programme of reactor components, particularly fuel elements, and the Authority was now building three heavy-water research and fuel-element-testing reactors to speed up this work. These reactors required heavy shielding and remote-handling facilities for examining the highly radioactive components. In addition, a so-called swimming-pool reactor was being built to study the design of reactor shields. It would have fuel elements containing about 3 kg. of highly enriched uranium and would operate at a power level of up to 1 MW.

Three British research reactors recently completed or under construction are shown in the accompanying illustrations. Fig. 1 is a view looking down on the core and reflector of ZEUS (Zero Energy Uranium System), which is an uncooled fast reactor and a full-scale model of the Dounreay installation (ENGINEERING, August 26, page 280, 1955). It has a large highly enriched uranium core with a natural-uranium blanket, and a rating of 100 watts. Fig. 2 shows the reactor container of DIDO (E.443, see ENGINEERING, August 19, page 235, 1955) arriving on site; the reactor building can be seen in the background. DIDO is a high-flux (5×10^{14}) heavy-water reactor with a rating of 10,000 kW. A model of the loop testing reactor PLUTO (R.E. 775) is illustrated in Fig. 3. PLUTO is a high-flux materials-testing reactor of 10,000 kW rating and construction has already begun. Basically similar to DIDO, it will have six test loops, each of which will provide a pilot model having the essentials of a future reactor system. Other Harwell research reactors are listed on page 265 (ENGINEERING, August 26, 1955) and LEO, a recent addition, is described on page 653 (ENGINEERING, November 11, 1955). The three illustrations are taken with kind permission from Atomic Energy Research Establishment photographs.

CHOICE OF REACTOR

Table I lists some of the alternative reactor systems offering prospects for the economic generation of electric power. An essential feature of the graphite-moderated reactors, which the White Paper refers to as Stage 1 reactors, Sir John continued, was that they would produce plutonium as a by-product that could be stockpiled and used for more highly rated reactors requiring enriched fuel in Stage 2 or Stage 3 of the programme. The White Paper envisaged a change to the more highly rated reactors of Stage 2 towards the end of the ten-year period. Higher ratings—up to 5 MW electrical output per ton of uranium—could probably be achieved by using water or liquid sodium as the heat-transfer medium.

The choice between heavy and light water depended to some extent on the availability of heavy water. In the United States light water had been chosen for three full-scale reactors but a paper presented to the Geneva Conference had shown that heavy water had marked advantages in reactors of more than 60 MW electrical output. Heavy-water reactors also seemed more docile to control, since they had longer reaction times.

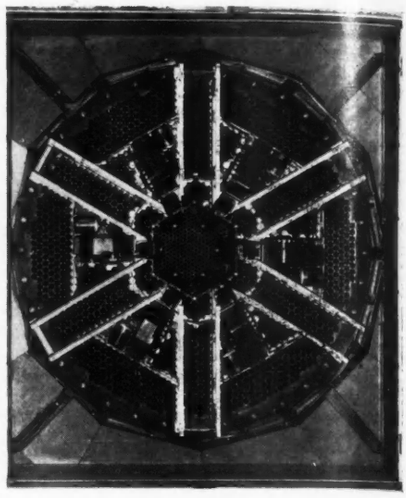

Fig. 1 View looking down on the core and reflector of the uncooled fast research reactor ZEUS. (A.E.R.E. photograph).

The choice between boiling and pressurised-water types of reactor had to be made mainly on engineering grounds. Boiling-water reactors had much lighter pressure vessels and components such as pumps, but they involved possible radioactive contamination of the turbine, and required highly leak-proof glands, especially for heavy water (D_2O).

FUEL BURN-UP AND RE-PROCESSING

Another important factor in the choice was the overall "burn-up" of fuel which could be achieved. A high burn-up depended on a high conversion ratio of U 235 to plutonium. A further consideration was the type of fuel element used. If the fuel was to be recycled many times it was important that chemical re-processing should be cheap. Thus a highly alloyed fuel element might lead to difficult waste-disposal problems, whereas an oxide fuel element, as used in the Westinghouse pressurised-water reactor, would be relatively cheap to process, and would not be corroded by hot water. Finally, there were safety problems to be considered in high-pressure systems carrying large amounts of radioactivity, and these greatly influenced the choice.

The United States with its enormous resources had decided that it was not possible at this stage to decide which was the "best" or most economic reactor. All of the more promising types were being built there so that the best could be selected for exploitation. Present feeling in the U.K.A.E.A., is that resources could be found by the Authority for only one Stage-2 reactor.

HOMOGENEOUS AND FAST REACTORS

Stage 3 of the programme aimed at breeding, either by homogeneous reactors using the U 233-Th fuel cycle, or the fast reactor using the Pu 239-U 238 fuel

TABLE I.—*Types of Reactor Offering Promise for Power Production for Stages 1, 2, and 3*

Stage	Type	Output, MW	Coolant	Fuel	Country of construction
1	Graphite-moderated	100-200	Gas	Nat. U.	U.K.
	Graphite-moderated	100	Water	Enriched U. 2·5 per cent. U235	U.S.S.R.
	Graphite-moderated	75	Sodium	Enriched U, 1·8 per cent. U235	U.S.A.
2	Pressurised water	75	Water	Enriched U, 1·6 per cent. U235	U.S.A.
	Boiling H_2O	180	Water	Enriched U	U.S.A.
	Boiling D_2O	10 (experimental)	—	Nat. U	Canada
3	Aqueous homogeneous	10 (experimental)	—	U233	—
	Liquid-metal-fuelled homogeneous	—	—	U233	—
	Fast breeder	60	—	Pu-U238 U235-U238	U.S.A. U.K.

cycle. Although work was proceeding vigorously on Stage-3 reactors it was thought that the development period would be long, and a large-scale contribution to nuclear power from such breeders was likely to be in the 1970's rather than the 1960's.

The Industrial Group was working closely with four industrial organisations on the design of the C.E.A. Stage-1 graphite-moderated power stations. The homogeneous reactor, which was part of the Stage-3 programme, was being studied with the help of the chemical industry, since it would be a highly specialised chemical plant with built-in facilities for continuous chemical processing of fuel.

Industry was also taking a major part in the design and construction of the new research reactors DIDO and PLUTO, and had already obtained an overseas order for one of these. Another industrial organisation was prepared to build swimming-pool types of reactor. The export of such reactors would, however, be limited by the availability of enriched fuel.

FUTURE ELECTRICITY RESOURCES

Presenting the paper entitled "The Place of Nuclear Energy in United Kingdom Power Development," of which he was joint author with Mr. Duckworth, Mr. Pask first reviewed future requirements for electricity and indicated the minimum nuclear power requirements if the import of fossil fuels was to be avoided. The factors justifying the decision to commence a nuclear power programme with graphite-moderated gas-cooled reactors were outlined and a comparison was made between the probable costs of generating electricity at the early nuclear power stations and costs typical of coal-fired base-load stations planned for commissioning by 1962. Future developments in power reactors and their fuel supplies were also discussed.

In the second part of the lecture, Mr. Pask dealt with the impact of base-load nuclear plant upon the design and operation of coal-fired plant, and upon schemes for pumped storage and the improvement of the night electricity load. He also considered the siting of nuclear power stations, and the economic consequences of nuclear power development.

It would be recalled that the recent Government White Paper outlined a provisional programme for the construction of nuclear power plants. This envisaged the commissioning of 12 nuclear stations by 1965, with a total net output capacity of between 1,500 and 2,000 MW. A total net output capacity of 10,000–15,000 MW. by 1975 was also foreseen.

In Table II, which was used to illustrate the lecture, item (5) shows the units required from thermal generating plant, and if an upper limit of coal available from Britain's own coalfields is assumed, it is possible to assess the minimum nuclear plant requirements to avoid importing fossil fuels. The assessment is made in Table III, where the allocation of home-produced coal for electricity supply is assumed to reach 60 million tons a year by 1970 and thereafter to remain at this level. In judging this figure it must be remembered that at present 36·9 million tons of the total requirements of 40·9 million tons are being supplied by home production, and that the estimate of total requirements by 1965 is more than 60 million tons a year. The units generated annually from the 60 million tons a year of coal (Table III (2)) reflect the continual advance expected in the efficiency of coal-fired stations. Table IV compares the capital costs of nuclear and coal-fired plant and Table V gives a comparison of the net generation cost for the two types of plant.

TABLE II.—*Total Power and Energy Requirements for Years* 1965/6 *to* 1980/1 (*estimated September*, 1955)

—	1965/6	1970/1	1975/6	1980/1
(1) Estimated peak demands, MW ..	34,500	43,500	55,500	70,500
(2) Total plant requirements, MW sent out	39,000	49,500	63,000	80,000
(3) Units sent out from generating stations, 10^6 kWh	136,000	176,000	229,000	295,000
(4) Units from hydro stations, 10^6 kWh	3,500	4,500	6,000	8,000
(5) Units required from thermal stations, 10^6 kWh ..	132,500	171,500	223,000	287,000

TABLE III.—*Power and Energy Required from Nuclear Fission for Years* 1965/6 *to* 1980/1 (*estimated September*, 1955)

—	1965/6	1970/1	1975/6	1980/1
(1) Units required from thermal stations, 10^6 kWh ..	132,500	171,500	223,000	287,000
(2) Units obtained from home produced coal, 10^6 kWh	107,000	131,000	136,500	140,500
(3) Units required from nuclear fission and/or imported fossil fuel, 10^6 kWh	25,500	40,500	86,500	146,500
(4) Nuclear capacity required to provide (3), MW sent out	3,900	6,000	13,000	23,000
(5) Assumed annual load factor of nuclear plant, per cent.	75·0	75·0	75·0	73·0
(6) Capacity of coal-fired plant required, MW sent out	33,500	42,000	48,000	54,500
(7) Average load factor of coal-fired plant, per cent.	36·4	35·6	32·4	29·4

PLUTONIUM AND OBSOLESCENCE

Mr. Pask went on to say that if, as was likely, the figures for costs from the first nuclear station lay somewhere between the two examples considered here, the net costs of generation should be very similar to those of the most up-to-date coal-fired plant. The price of plutonium would probably remain fairly high until sometime during the 1970s, as the demand for pure fissile material was likely to keep pace with the increasing supplies during the next 15 years or so.

Even if the price of plutonium did fall more than expected, or earlier than expected, that would not mean that the early designs of reactors, which have been justified on the basis of a reasonably good price for plutonium, would immediately become white elephants. There would still be the possibility of re-cycling the plutonium in the reactor which produced it, thus reducing the amount of natural uranium required. The exact way in which the plutonium would be fed to the reactor is uncertain. It could be blended with the depleted uranium feed but this would mean that the fabrication of a large quantity of metal from that stage on would have to be carried out under alpha-active conditions. Alternatively, plutonium could be mixed with some low neutron-absorbing diluent and introduced as separate elements, but the rate of heat production in these elements would fall off rather rapidly.

More advanced types of reactor would eventually supersede the gas-cooled type, but while the prototypes were being proved, improvements would be made to the gas-cooled type, and it might be many years before it was superseded. Improvements in heat-transfer surfaces, metallurgical developments permitting higher temperatures, and possibly the use of a different coolant gas might together lead to great advances in heat rating and overall efficiency.

ENGINEERING PROBLEMS OF TO-MORROW

It was, nevertheless, interesting to look at some of these future possibilities, particularly those with the unique property of producing more fissile material than they consumed. The first competitor of the gas-cooled reactor was likely to be the light-water-cooled and moderated reactor. This required enriched fuel, since light water absorbed neutrons more readily than graphite and carbon dioxide. The greatly superior qualities of light water as a moderator and heat-transfer medium would, it was hoped, permit greatly increased reactor heat ratings and consequently reduced capital costs per kW, even after allowing for separately fired superheaters to improve the steam cycle. The light-water-cooled and moderated reactor, however, presented problems of its own. Firstly, the high vapour pressure of water introduced the problem of housing the reactor in a 1,000 lb. per square inch pressure vessel to achieve even the moderate temperature of 550 deg. F. Secondly, water dissociated under irradiation into hydrogen and hydrogen peroxide, and when impurities were present the equilibrium pressure could reach several atmospheres. Thus the designer was faced with the problem of dealing with a gas mixture which was both radioactive and explosive. Thirdly, the corrosive properties of water under such conditions and at such temperatures as 550 deg. F. and such pressures as 1,000 lb. per square inch needed considerable investigation.

The Th-U 233 fuel cycle had properties which suggested the possibility of achieving a zero or positive gain factor (that is of producing as much as or more fissile material than was consumed) in a slow-neutron reactor. This development would not be possible, however, until the technology of thorium was sufficiently developed and adequate supplies of pure fissile material were available to start the thorium reactors. There would be an incentive here to increase research on the homogeneous reactor, with its attendant difficulties and advantages. This type, in which the fuel was uniformly dispersed throughout the moderator, would have a higher gain factor than the heterogeneous type in which fuel elements were arranged in a moderator lattice.

To be continued

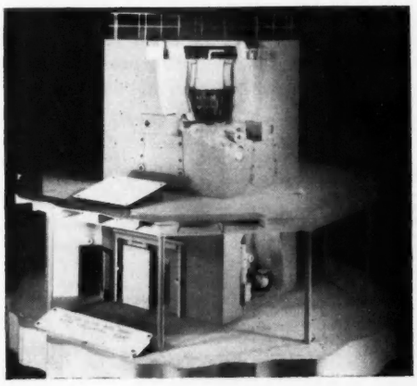

Fig. 3 Each of the six test loops of PLUTO (a model of which is shown here) will provide a pilot model of a future reactor system. PLUTO is a high-flux materials-testing reactor. (A.E.R.E. photograph).

TABLE IV.—*Comparison of Costs of Nuclear and Coal-fired Plant.*

—	(1) Nuclear station of 200 MW s.o. 3,000 MWD per tonne	(2) Nuclear station of 170 MW s.o. 2,000 MWD per tonne	(3) Coal-fired base-load plant.	(4) Coal-fired base-load plant on coal-fields
Load factor	75 per cent.	75 per cent.	69 per cent. average	75 per cent.
	£ per kW s.o.	£ per kW s.o.	£ per kW s.o.	£ per kW s.o.
Construction cost ..	125	150	54·3	54·3
Cost of initial charge of fuel	24	30	—	—
Total capital cost ..	150	180	54·3	54·3
	Pence per unit s.o.	Pence per unit s.o.	Pence per unit s.o.	Pence per unit s.o.
Annual charges on construction cost	0·336	0·403	0·129	0·119
Annual interest on initial charge of fuel ..	0·036	0·044	—	—
Other works costs ..	0·06	0·07	0·052	0·049
Annual fuel cost ..	0·266	0·4	0·375	0·351
Gross generation ..	0·698	0·917	0·556	0·519

TABLE V.—*Comparison of Net Generation Costs of Nuclear and Coal-fired Plant.*

—	(1) Nuclear station of 200 MW s.o. 3,000 MWD per tonne	(2) Nuclear station of 170 MW s.o. 2,000 MWD per tonne	(3) Coal-fired base-load plant	(4) Coal-fired base-load plant on coal-fields
Load factor	75 per cent.	75 per cent.	69 per cent. average	75 per cent.
	Pence per unit s.o.	Pence per unit s.o.	Pence per unit s.o.	Pence per unit s.o.
Gross generation cost ..	0·698	0·917	0·556	0·519
Credit for plutonium at £10,000 per kg. ..	0·266	0·266	—	—
Net generation cost ..	0·432	0·651	0·556	0·519

★ ★ ★

CORROSION RESISTANT PUMPS

A range of centrifugal pumps made of materials having high resistance to corrosion has been introduced by Worthington-Simpson Limited, Newark, Nottinghamshire, for handling chemicals. The range covers outputs up to 675 gallons per minute with heads up to 125 ft. At full capacity, the maximum suction lift is 15 ft.

Alternative materials are Worthite—which is particularly suitable for handling sulphuric acid —and 18/8/3 stainless steel, which is suitable for mild corrosives. Either stuffing-box packing or mechanical seals can be fitted as desired.

NOTICES OF MEETINGS

Association of Supervising Electrical Engineers

BIRMINGHAM
Film Evening. Birmingham Branch. Chamber of Commerce, 95 New-street, Birmingham. Wed., Dec. 14, 7.15 p.m.
OXFORD
"Motor Fault Tracing," by W. G. Wrigley. Oxford and Reading Branch. 10 George-street, Oxford. Sat., Dec. 17, 6.30 p.m.
WEMBLEY
"Industrial Electronics," by C. J. Teece. North West London Branch. Century Hotel, Forty-avenue, Wembley Park. Mon., Dec. 12, 8.15 p.m.
YORK
"Uses of Infra-Red and Ultra-Violet Lamps," by H. Laycock. York Branch. Shambles Café, York. Wed., Dec. 14, 7.15 p.m.

British Institution of Radio Engineers

LONDON
"The Remote Presentation of Radar Information," by G. J. Dixon and H. H. Thomas. London Section. London School of Hygiene and Tropical Medicine, Keppel-street, W.C.1. Wed., Dec. 14, 6.30 p.m.
NEWCASTLE-UPON-TYNE
"The Metal-Cone Loudspeaker," by W. I. Heath. North Eastern Section. Neville Hall, Westgate-road, Newcastle-upon-Tyne. Wed., Dec. 14, 6 p.m.
WOLVERHAMPTON
"Television Aerial Design, with Emphasis on Band III Problems," by I. A. Davidson. West Midlands Section. Wolverhampton and Staffordshire Technical College, Wulfruna-street, Wolverhampton. Wed., Dec. 14, 7.15 p.m.

British Welding Research Association

MANCHESTER
Symposium on "Increasing Productivity by the Use of Welding." Lesser Free Trade Hall, Peter-street, Manchester. Tues. and Wed., Dec. 13 and 14, 9.30 a.m. and 2.30 p.m. (Admission by ticket.)

Building Centre

LONDON
Films on "Concreting and Decorating." Wed., Dec. 14, 12.45 p.m.

Chemical Society

LONDON
"Delocalised Metal-Carbon Bonds," by L. E. Orgel; "Ferrocene Derivatives," Part III, by B. F. Hallam and P. L. Pauson; and "Complexes of Uncharged Aromatic Systems with Transition Metals and the Bonding Problem of Ferrocene and Similar Compounds," by E. O. Fischer. Thurs., Dec. 15, 7.30 p.m.

Diesel Engineers and Users Association

LONDON
"Report on Heavy Oil Engine Working Costs and Performance, 1954"; and Discussion on "Operating Problems." Caxton Hall, Victoria-street, S.W.1. Thurs., Dec. 15, 2.30 p.m.

Illuminating Engineering Society

LONDON
"Lighting in Buildings: Training and Practice," by Derek Phillips. Lighting Service Bureau, 2 Savoy-hill, W.C.2. Tues., Dec. 13, 6 p.m.*
BIRMINGHAM
"Lighting Problems in Laboratories," by P. S. Crowther and W. H. Pritchard. Birmingham Centre. Regent House, St. Phillip's-place, Colmore-row, Birmingham. Fri., Dec. 16, 6 p.m.
MANCHESTER
"Fading and Related Effects Associated with Radiation from Light Sources," by B. S. Cooper. Manchester Centre. Offices of the North Western Electricity Board, Town Hall Extension, Manchester. Thurs., Dec. 15, 6 p.m.
SHEFFIELD
Various short papers. Sheffield Centre. Medical Laboratory, The University, Western Bank, Sheffield, 10. Mon., Dec. 12, 6.30 p.m.

Incorporated Plant Engineers

BLACKBURN
"Fabrication in a Modern Welding Shop," by R. M. Watts. Blackburn Branch. Golden Lion Hotel, Blackburn. Thurs., Dec. 15, 7.30 p.m.
BRISTOL
"Plant Engineers and Management," by W. J. Dickie. Western Branch. Grand Hotel, Bristol. Wed., Dec. 14, 7.15 p.m.
DUNDEE
"Tar-Distillation Plant," by R. M. Crighton. Dundee Branch. Mathers Hotel, Dundee. Mon., Dec. 12, 7.30 p.m.
MANCHESTER
Discussion on "Corrosion Technology." Manchester Branch. Engineers' Club, Albert-square, Manchester. Tues., Dec. 13, 7.15 p.m.
NOTTINGHAM
"Grit and Dust Collection from Industrial Furnaces," by J. E. O'Breen. East Midlands Branch. County Hotel, Theatre-square, Nottingham. Wed., Dec. 14, 7 p.m.

Institute of Fuel

BIRMINGHAM
Discussion on "Fuel Problems." Midland Section. Exchange and Engineering Centre, Stephenson-place, Birmingham. Wed., Dec. 14, 6 p.m.
LIVERPOOL
"Instrumentation of Boilers," by R. Clare. Merseyside Sub-Section. 9 The Temple, 24 Dale-street, Liverpool. Thurs., Dec. 15, 7 p.m.
NEWCASTLE-UPON-TYNE
"The Complete Gasification of Coal," by Dr. F. J. Dent. North Eastern Section. King's College, Newcastle-upon-Tyne. Mon., Dec. 12, 6.30 p.m.
NOTTINGHAM
"Grit and Dust Collection from Industrial Furnaces," by J. E. O'Breen. East Midland Section. County Hotel, Nottingham. Wed., Dec. 14, 7 p.m.

Institute of Marine Engineers

LONDON
"Carriage of Edible Oil and Similar Bulk Cargoes," by John Wormald. Tues., Dec. 13, 5.30 p.m.*

Institute of Petroleum

LONDON
"Statistics as an Aid to Specification," by G. W. Sears. Wed., Dec. 14, 5.30 p.m.*

Institute of Road Transport Engineers

LONDON
"Maintaining a Mixed Dispersed Fleet," by W. L. Gage. Royal Society of Arts, John Adam-street, W.C.2. Thurs., Dec. 15, 6.30 p.m.
BEDFORD
"Development of the Light-Weight Diesel," by H. L. Parrish. Eastern Centre. Swan Hotel, Bedford. Tues., Dec. 13, 7 p.m.
EDINBURGH
"Mobile Cranes in Relation to Transport," by C. S. Shaw. Scottish Centre. North British Hotel, Edinburgh. Mon., Dec. 12, 7.30 p.m.
LEEDS
"Manufacture, Operation and Maintenance of Passenger and Commercial Vehicle Batteries," by V. A. Lord. Yorkshire Centre. Great Northern Hotel, Wellington-street, Leeds 1. Thurs., Dec. 15, 7.30 p.m.

Institution of British Agricultural Engineers

LONDON
"Factors in the Design of Tractor-Mounted Loaders," by Eric Alley. Tues., Dec. 13, 6 p.m.*

Institution of Chemical Engineers

MANCHESTER
"Some Aspects of Heat Transfer in a Climbing Film Evaporator," by Professor J. M. Coulson. North Western Branch. College of Technology, Manchester. Sat., Dec. 17, 3 p.m.

Institution of Civil Engineers

LONDON
Parsons Memorial Lecture on "The Development of the Gas Turbine," by Sir Harold Roxbee Cox. Tues., Dec. 13, 5.30 p.m.*
Rankine Memorial Lecture, by Sir Richard Southwell. Thurs., Dec. 15, 5.30 p.m.*
HULL
Various short papers. Yorkshire Association. Electricity Showrooms, Ferensway, Hull. Wed., Dec. 14, 6.15 p.m.*
PRESTON
"Non-Rigid Types of Road Construction," by A. J. Lyddon. North Western Association. County Hall, Preston. Wed., Dec. 14, 5.45 p.m.

Institution of Electrical Engineers

LONDON
"The Television Studio as Seen by the Producer," by Alvin Rakoff. Radio and Telecommunication Section. Mon., Dec. 12, 5.30 p.m.*
"The Measurement of Steam Temperatures in Power Stations," by D. H. Lucas and M. E. Peplow. Supply Section. Wed., Dec. 14, 5.30 p.m.*
"Intensification of the X-Ray Image in Industrial Radiology," by Dr. A. Nemet and W. F. Cox. Utilization Section. Thurs., Dec. 15, 5.30 p.m.*
"Colour Television," by L. A. Harris. London Graduates' and Students' Section. Tues., Dec. 13, 6.30 p.m.*
CHESTER
"Electrical and Magnetic Measurements in an Electrical Engineering Factory," by D. Edmundson. Mersey and North Wales Centre. Town Hall, Chester. Mon., Dec. 12, 6.30 p.m.
FARNBOROUGH
"The Use of Transistors in Computer-Type Circuits," by G. B. B. Chaplin. Southern Centre. Royal Aircraft Establishment Technical College, Farnborough. Wed., Dec. 14, 7.30 p.m.
NOTTINGHAM
Faraday Lecture on "Coal Mining Electrically," by B. L. Metcalf. East Midland Centre. Albert Hall, Nottingham. Thurs., Dec. 15, 7.15 p.m. (Tickets obtainable from Dr. W. Alexander, The University, Nottingham.)

Institution of Engineering Inspection

LONDON
"The Motor Industry Research Association: Its Purpose, Organisation and Methods," by W. G. Stevenson. Royal Society of Arts, John Adam-street, W.C.2. Wed., Dec. 14, 6.45 p.m.

Institution of Engineers-in-Charge

LONDON
"Bouellat Radiant Water-Tube Boilers," by Miss J. E. Gardiner. St. Bride Institute, Bride-lane, E.C.4. Wed., Dec. 14, 6.30 p.m.*

Institution of Engineers and Shipbuilders in Scotland

GLASGOW
"Light Structures: Research and Its Application to Economic Design," by R. M. Kenedi, W. Shearer Smith and F. Fahmy. Tues., Dec. 13, 7.30 p.m.

Institution of Heating and Ventilating Engineers

LEICESTER
"Noise in Ventilation Ducts," by W. P. Jones. East Midlands Branch. College of Technology, Leicester. Wed., Dec. 14, 6.45 p.m.
NEWCASTLE-UPON-TYNE
"Fan Types and Their Choice," by H. W. Brown. North East Coast Branch. Neville Hall, Westgate-road, Newcastle-upon-Tyne. Tues., Dec. 13, 6.30 p.m.

Institution of Locomotive Engineers

LONDON
"Locomotives for Heavy Industry," by C. Wordsworth. Institution of Mechanical Engineers, 1 Birdcage-walk, St. James's Park, S.W.1. Wed., Dec. 14, 5.30 p.m.*

Institution of Mechanical Engineers

LONDON
"Carburation and Allied Problems," by C. H. Fisher. Automobile Division. Tues., Dec. 13, 5.30 p.m.*
"Pressurised Water Reactor as a Source of Heat for Steam Power Plants," by Dr. J. M. Kay and F. J. Hutchinson. In conjunction with British Nuclear Energy Conference. At Institution of Civil Engineers, Great George-street, S.W.1. Wed., Dec. 14, 5.30 p.m.*
Discussion on "Filtration of Liquids." Hydraulics Group. Thurs., Dec. 15, 6.45 p.m.*
James Clayton Lecture on "Supply Control and Combustion of Fuel to Aero-Gas-Turbines," by Dr. E. A. Watson. Fri., Dec. 16, 5.30 p.m.*
MIDDLESBROUGH
"Development of Mechanical-Draught Water-Cooling Towers," by L. Gilling Smith and G. W. Williamson. North Eastern Branch. Cleveland Institute, Middlesbrough. Wed., Dec. 14, 6.15 p.m.
SHEFFIELD
"Development and Scope of Work Study," by G. Case. Yorkshire Branch. The University, Sheffield. Wed., Dec. 14, 6.30 p.m.
SWANSEA
"The Roll-Setting Method of Automatic Control of Gauge in Hot and Cold Rolling Mills," by R. B. Sims and K. H. Slack. South Wales Branch. Mackworth Hotel, Swansea. Tues., Dec. 13, 6 p.m.

Institution of Mining and Metallurgy

LONDON
"Panel Carving at the Creighton Nickel Mine, Canada," by A. F. Brock and others; and "Equipping No. 3 Shaft, Harmony Gold Mining Co.," by S. C. Newman. Geological Society, Burlington House, Piccadilly, W.1. Thurs., Dec. 15, 5 p.m.*

Institution of Production Engineers

LONDON
Viscount Nuffield Paper: "Britain's Energy Prospects," by Dr. G. H. Daniel. Royal Institution, Albemarle-street, W.1. Thurs., Dec. 15, 6.30 p.m.*
"Industrial Diamonds," by E. W. Marks. Tues., Dec. 13, 7.15 p.m.
SHEFFIELD
"Fabrication for Heavy Engineering," by J. A. M. Stirling and R. Bagshaw. Grand Hotel, Sheffield. Mon., Dec. 12, 6.30 p.m.
WOLVERHAMPTON
"Implications of Automation," by F. G. Woollard. Technical College, Wulfruna-street, Wolverhampton. Wed., Dec. 14, 7 p.m.

Institution of Public Health Engineers

LONDON
"Biology of Rivers in Relation to Pollution," by F. T. K. Pentelow. Caxton Hall, Victoria-street, S.W.1. Tues., Dec. 13, 6 p.m.

Institution of Railway Signal Engineers

LONDON
"Testing of Mechanical Interlocking," by W. L. Cartwright. Institution of Electrical Engineers, Savoy-place, W.C.2. Tues., Dec. 13, 6 p.m.*

Institution of Structural Engineers

LONDON
"Tignes Hydro-Electric Scheme," by R. Giguet. Fri., Dec. 16, 6 p.m. (Alteration of date).

Junior Institution of Engineers

LONDON
Gadget Evening. Fri., Dec. 16, 7 p.m.
MANCHESTER
"Choice of Lubricants," by S. E. Holmes. Engineers' Club, Albert-square, Manchester. Mon., Dec. 12, 7.30 p.m.
SHEFFIELD
"Motor Bus Maintenance," by T. F. Bailey. Livesey Clegg House, Union-street, Sheffield. Mon., Dec. 12, 7.30 p.m.

Newcomen Society

LONDON
"Waterwheels of John Smeaton," by P. N. Wilson. Wed., Dec. 14, 5.30 p.m.

Royal Aeronautical Society

LONDON
"Airships of To-Day," by Lord Ventry. Fri., Dec. 16, 7 p.m.

The address and telephone number of the headquarters of each institution are given below. Meetings in the headquarters town are held there unless otherwise stated. Particulars for this column should reach the Editor not later than Monday morning in the week preceding the date of the meeting.

* An asterisk is placed where it is understood that tea is available prior to the time stated.

Association of Supervising Electrical Engineers, 23 Bloomsbury-square, London, W.C.1. (LANgham 5927.)
British Institution of Radio Engineers, 9 Bedford-square, London, W.C.1. (MUSeum 1901.)
British Welding Research Association, 29 Park-crescent, London, W.1. (LANgham 7485.)
Building Centre, 26 Store-street, London, W.C.1. (MUSeum 5400.)
Chemical Society, Burlington House, Piccadilly, London, W.1. (REGent 0675.)
Diesel Engineers and Users Association, 56 Victoria-street, London, S.W.1. (VICtoria 6161.)
Illuminating Engineering Society, 32 Victoria-street, London, S.W.1. (ABBey 5215.)
Incorporated Plant Engineers, 48 Drury-lane, Solihull, Birmingham. (Solihull 3021.)
Institute of Fuel, 18 Devonshire-street, Portland-place, London, W.1. (LANgham 7124.)
Institute of Marine Engineers, 85 The Minories, London, E.C.3. (ROYal 8493.)
Institute of Petroleum, Manson House, 26 Portland-place, London, W.1. (LANgham 2250.)
Institute of Road Transport Engineers, 69 Victoria-street, London, S.W.1. (ABBey 6248.)
Institution of British Agricultural Engineers, 6 Buckingham-gate, London, S.W.1.
Institution of Chemical Engineers, 56 Victoria-street, London, S.W.1. (VICtoria 6161.)
Institution of Civil Engineers, Great George-street, London, S.W.1. (WHItehall 4577.)
Institution of Electrical Engineers, Savoy-place, Victoria-embankment, London, W.C.2. (TEMple Bar 7676.)
Institution of Engineering Inspection, 28 Victoria-street, London, S.W.1. (ABBey 3794.)
Institution of Engineers-in-Charge, 100 Earlsfield-road, London, S.W.18. (BATtersea 1394.)
Institution of Engineers and Shipbuilders in Scotland, 39 Elmbank-crescent, Glasgow, C.2. (Central 5181.)
Institution of Heating and Ventilating Engineers, 49 Cadogan-square, London, S.W.1. (SLOane 3158.)
Institution of Locomotive Engineers, 28 Victoria-street, London, S.W.1. (ABBey 6672.)
Institution of Mechanical Engineers, 1 Birdcage-walk, St. James's Park, London, S.W.1. (WHItehall 7476.)
Institution of Mining and Metallurgy, 44 Portland-place, London, W.1. (LANgham 3802.)
Institution of Production Engineers, 10 Chesterfield-street, London, W.1. (GROsvenor 5254.)
Institution of Public Health Engineers, 118 Victoria-street, London, S.W.1. (VICtoria 3017.)
Institution of Railway Signal Engineers, Euston House, Eversholt-street, London, N.W.1.
Institution of Structural Engineers, 11 Upper Belgrave-street, London, S.W.1. (SLOane 7128.)
Junior Institution of Engineers, Pepys House, 14 Rochester-row, London, S.W.1. (VICtoria 0786.)
Newcomen Society, Science Museum, Exhibition-road, London, S.W.7. (KENsington 1793.)
Royal Aeronautical Society, 4 Hamilton-place, London, W.1. (GROsvenor 3515.)

In Parliament

SUPPORT FOR CIVIL AIRCRAFT

A number of matters of aeronautical interest came before the House of Commons last week. On Monday, it was the turn of the Vickers 1000 aircraft to be discussed. Mr. Reginald Maudling, Minister of Supply, stated that it had taken longer than was hoped to overcome some of the problems of meeting the specification laid down for this aircraft. In these circumstances, and in view of the urgency of the need to re-equip Transport Command, it had been decided to take the long-range Britannia, which had been developing well and which could be made available earlier. The contracts for one prototype and six production aircraft had accordingly been cancelled. It was not intended to provide public funds for the development of a civil version of the V.1000 as the British Overseas Airways Corporation had no requirement for it.

Replying to Mr. Paul Williams (Unionist), who had emphasised the support given by the United States Government to civil-aircraft development in America, Mr. Maudling said that the Government rightly did a great deal to assist the development of civil aircraft, but the point in this case was that they could not support the development of an aircraft when there was no home operator willing to purchase it.

Mr. J. Rankin (Labour) inquired where the knowledge gained in the construction of the Brabazon aircraft had fled and said that, at the time of the scrapping of that aircraft, the expenditure on it had been defended on the ground that it had provided the knowledge that would solve " all the problems associated with the building of heavy aircraft of that nature". Mr. George A. Brown (Labour) asked if it was not rather unfair to lay the Government's decision on the alleged lateness by the firm, as, although the prototype was a year late, the firm claimed that it could deliver the aircraft by the original flying date, namely in 1960 or 1961.

Mr. Maudling replied that much of the work done on the Brabazon had gone into the development of the Britannia as the first long-range trans-Atlantic turbo-prop aircraft. He denied that the decision had been due to any demand that his Department must economise and affirmed that the original date for the V.1000 was well before 1960 and could not be met.

AERONAUTICAL RESEARCH AND DEVELOPMENT

Among other aeronautical matters dealt with later was the question of research. In answer to a point raised by Viscount Hinchingbrooke (Unionist), Mr. Maudling said that where research or development projects were of a purely military nature and promoted by the Ministry of Supply, or were the result of Service requirements, it was normal for the cost to be borne by his Department. Where such projects had commercial possibilities, the contribution from public funds was a matter for negotiation.

He told Wing Commander E. E. Bullus (Unionist) that development contracts were placed with companies able to do the work, irrespective of their membership of the Society of British Aircraft Constructors. Licences for the manufacture of Vampire jet aircraft, he informed Mr. Barnett Janner (Labour), had been granted to Switzerland, France, Italy, India and Australia, or to manufacturers in those countries, in that order.

As to long-range jet aircraft for North Atlantic passenger operations, the de Havilland Comet 4, Mr. Maudling informed Mr. Frank Beswick (Labour), would be suitable for that route, with a single re-fuelling stop. If, in the early 1960's, Britain did not have a straight-jet non-stop trans-Atlantic aircraft neither would the Americans have a non-stop trans-Atlantic turbo-prop aircraft.

About 270 of the modifications made to the Valiant and approved up to November 11 last had originated in the Ministry of Supply. The remaining 700 were either originated in the Air Ministry or put forward by the contractor. This number was a fairly reasonable one and compared reasonably with the experience of the United States with similar aircraft.

Technical Progress in Nationalised Industries

Mr. E. Shinwell (Labour) urged that the Minister of Fuel and Power should publish, either in Hansard or as a White Paper, a statement showing the progress made by the nationalised fuel and power industries in the development and production of by-products. He was aware of the reports published already, but they were very difficult to follow and the development of by-products was one of the main elements of progress in these industries. Mr. L. Joynson-Hicks, Parliamentary Secretary to the Ministry, said that a special statement would involve simply the reproduction of a summary of sections of individual annual reports. If this were done for one purpose, it would be thought desirable to do it for others. The reports were carefully indexed and the information seemed quite readily available.

Refitting of Naval Vessels

An assurance was given by Commander Allan Noble, R.N. (ret.), Parliamentary and Financial Secretary to the Admiralty, to Brigadier T. H. Clarke (Unionist) that priority would be given to refitting ships of the Royal Navy at H.M. Dockyards. Commander Noble said that no exact comparison could be made between the relative costs of refitting work in the Royal Dockyards and private shipyards on the Clyde—or elsewhere in the country. To such extent as comparison was possible, costs in the Royal Dockyards were rather lower, as indeed they should be since the primary task of these yards was the repair of warships and the private yards were concerned more with merchant vessels.

Aircraft Carriers Scrapped

Commander Noble told Mr. L. J. Callaghan (Labour) that it had always been naval policy that ships should be disposed of when they had reached a condition when further expenditure on modernisation and maintenance would not be justified, in order to allow financial resources to be devoted to newer vessels. This policy was being followed particularly in the Reserve Fleet where the emphasis was now being put on achieving a higher standard of readiness. As a result, some ships, including two aircraft carriers, had been disposed of during this year and others would follow shortly. These vessels were mainly of war construction and had seen heavy service.

Inter-Governmental Maritime Organisation

In a written reply to Mr. F. T. Willey (Labour), Lord John Hope, Joint Parliamentary Under-Secretary of State for Foreign Affairs, stated that the Government fully agreed with the aims of the Inter-Governmental Maritime Consultative Organisation. These were to encourage the highest possible standards of maritime safety, to discourage discriminatory and restrictive practices in international shipping, and to provide a world-wide forum for the discussion and exchange of information between Governments. Twenty-one ratifications would be necessary to bring the Convention into force and, so far, 18 Governments, including that of the United Kingdom, had ratified it. Several others were understood to have the matter under active consideration.

Technical Assistance to Singapore and Malaya

The Secretary of State for the Colonies, Mr. Alan Lennox-Boyd, informed Mr. S. S. Awbery (Labour) that no portion of the contribution of £7 million which the Government were to make to the Colombo Plan Technical Co-operation Scheme, in aid of under-developed countries, would be spent on technical assistance for Singapore or the Federation of Malaya. Such assistance was given by the United Kingdom to those countries in other ways.

Railway Electrification in S.W. Scotland

Mr. John Boyd-Carpenter, the Minister of Transport and Civil Aviation, told Mr. Tom Steele (Labour) that a proposal to electrify certain suburban railways in and around Glasgow, as suggested by the Inglis committee, had been approved in principle by the British Transport Commission. This approval was subject to the conclusion of a statisfactory agreement with the Glasgow Corporation for the co-ordination of transport facilities in the area. Negotiations with the Corporation were proceeding.

Statutory Minimum Wages

Sir Walter Monckton, Minister of Labour and National Service, said, in reply to a question by Mr. A. W. J. Lewis (Labour), that 53 wages boards and councils had submitted to him 60 proposals for increases in statutory minimum renumeration since November 30, 1954. The number of employees affected was between 2 and 2½ millions. Of the wages councils concerned, six had submitted proposals for wage increases since October 26 last, when the Budget was introduced, but these proposals had been formulated and published before that date.

Tenders for N.A.T.O. Contracts

A question was asked by Mr. C. J. McCall Alport (Unionist) as to whether the Minister of Defence was aware of the difficulties facing British firms tendering for North Atlantic Treaty Organisation contracts, particularly those in relation to the central section pipeline project. Mr. Selwyn Lloyd replied that he was aware of these problems. The Government were considering the desirability of proposing further changes in the present approved practices and procedures for awarding Infrastructure contracts, but it would be appreciated that any such changes must be accepted by all countries concerned before they could become effective and, in matters of this kind, compromises were usually necessary in the interests of N.A.T.O. as a whole. In the meantime, the Government would continue to give support, within present practices and procedures, to British firms submitting tenders for Infrastructure contracts.

Iron and Steel Import Duty

The President of the Board of Trade, Mr. Peter Thorneycroft, informed Mr. Martin Lindsay (Unionist) in a written answer that the import duty on most iron and steel products was suspended until March 18, 1956, by an Order made on July 13, 1955. Mr. Thorneycroft added that he had recently received the views of the Iron and Steel Board on the question of a further suspension of duty on these products and that he was now considering the matter in the light of those views. The Government's decision would be made known as soon as possible.

Nickel Supplies

By far the greater part of Britain's supplies of nickel, Mr. Thorneycroft informed Mr. Frederick Lee (Labour), came from Canada. There was a world shortage of this metal, in consequence of which some British manufacturers were getting less than they could use and were unable to build up their stocks. Manufacturers were buying increasing quantities from other sources, mainly from New Calendonia, but the amounts obtainable were comparatively small.

Automation in Industry

Mr. J. R. Bevins, Parliamentary Secretary to the Ministry of Works, informed Lieut.-Colonel M. Lipton (Labour) that it was hoped that the report which the Department of Scientific and Industrial Research was preparing on automation in industry would be in the hands of the printers early in the New Year.

Employment in Factory Inspectorate

In answer to a written question from Mr. Frederick Lee, the Parliamentary Secretary to the Ministry of Labour and National Service, Mr. Harold Watkinson, said that there were ten vacancies in the Factory Inspectorate for which no successful candidates had so far been forthcoming. Ten inspectors had left the service this year and one more was known to be leaving. Most of those concerned were taking up employment in industry or in education. The wastage would be made good by ordinary recruitment.

THE HUMAN ELEMENT

Must the Civil Service always increase in size?—Outstanding wage claims to the Transport Commission—Court ruling on trade union revenue procedure—British attitudes to automation—and American—Permitted earnings of old-age pensioners.

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Reducing the Civil Service

Hard on the heels of the findings of the Royal Commission on the Civil Service about pay and working conditions has come a White Paper (Cmd. 9637) on numbers employed in the Service. It points out that, although there has been a slight increase in Post Office staff on a temporary basis to help reduce the telephone waiting list, the total Service is 2,000 smaller than a year ago. The non-industrial Civil Service is down by 7½ per cent. since January, 1952.

Since the effect of the Royal Commission's recommendations, if accepted, will be to reduce overtime in the Service and correspondingly increase staff, this White Paper may be unique of its kind. It may be the last to record a drop in numbers for a long time. There is indeed a long-term trend for the Civil Service to increase—quite apart from the current joke about bureaucratic "laws" of empire building. As horse-power per worker or electric power units per worker increase, the amount of brain power per unit of output must also increase. This is another way of saying that there must be more technicians and fewer routine operatives. In such circumstances it is likely that the Civil Service will grow roughly in proportion.

All the more reason therefore arises to see that it does not grow out of proportion. Mechanisation must come to the Civil Service to replace lower paid clerical workers just as it is coming elsewhere. Modern and rigorous methods of budgetary control must be employed to keep administrative overheads down, just as large companies have had to employ them. There never was an administrative machine (even when disciplined by the profit and loss account) which did not try to grow more quickly than it need. When the trend is toward growth there is all the more need for scrutiny. At present, mechanisation and control techniques have a long way to go in Government departments. Under these conditions, the price of efficient staffing is eternal vigilance.

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Railway Pay Claims

December 13 has been fixed by the British Transport Commission for hearing the arguments from the National Union of Railwaymen for an increase of 10 per cent. in their members' wages; they will deal, too, with the 7½ per cent. claim from the Transport Salaried Staffs Association at the same series of meetings. There is also pending the engineering shop workers' claim (as well as the parallel claim which has been made to the London Transport Executive for shop workers in its employ) and discussions with the A.S.L.E.F. are still going on. The total claims outstanding would, if granted, put a further serious strain on British Railways at a time when they are operating at a loss and are seriously circumscribed in the rate at which they can increase productivity.

Ill-feeling among the unions themselves is a further irritant to an already serious negotiating situation. There are still echoes from the strike last summer. Last week, one of the A.S.L.E.F. branches found it necessary to put out a notice that there had been no persecution of non-strikers; nothing had been done or would be done by the union to foment trouble between members and other union staff. In matters of this sort there is never smoke without fire; it is no gain to the unions concerned, the British Transport Commission or the travelling public, to have this sort of thing smouldering at a time when critical wage negotiations have to be undertaken.

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Trade Union Levies

A ruling by the Court of Appeal has forbidden trade unions to make a levy on a proportion only of their membership. The circumstances of the case from the point of view of the union were understandable enough. The Musicians' Union wished to raise additional resources for the general office fund but presumably did not wish to make a flat levy on members who are in a profession where earnings fluctuate notoriously. They therefore proposed exempting those members whose earnings fell below a certain level each week.

The Court was called upon to interpret the union's rules and the issue was one of exemption. Their Lordships were not concerned to give a ruling on the issue of a graduated levy on all members. On the issue under appeal (the matter had been brought from a lower court by the union concerned) they dismissed the case. The union therefore lost the argument.

There are two points in this matter. First, a legal precedent has been established on the issue of exemption from a union levy. A second point, and one which may in the short run be the more important for the trade union movement, is the question whether this kind of procedure is in the interests of a union when it faces a financial problem. Must union members have recourse to the courts when their union funds are low? It is one sure way of mortgaging increased subscriptions before they have been collected.

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Automation Fears....

Last week a group of shop stewards from the Midlands were lobbying M.P's at the House of Commons on the subject of automation in the motor industry. Also last week, it was announced that the trade-union group of the Labour Party would soon embark on a study of the likely effects of automation on industry. Mr. Robert Edwards, a Labour M.P., who is also general secretary of the Chemical Workers' Union, is the sponsor of a Bill which proposes the establishment of a permanent committee "to inquire into, review and report on the social, educational, cultural, and economic needs and consequences of the application of automation and electronic devices to British industry and agriculture."

This nervous concern which is greeting the appearance of automation—often represented as a monster feeding greedily on men's jobs—has been countered by a few reassuring noises on the other side of the fence. Sir Ivan Stedeford, head of Tube Investments, Limited, thinks that far from being a threat to full employment it may—by lightening and reducing manual work and by increasing the need for engineers to make, man and maintain the automatic equipment—raise the general level of education and well-being of the country as a whole. Sir Walter Monckton, who does not under-estimate the problems this new concept of production will create, considers that it increases rather than diminishes the need for skilled labour, for scientists and for technologists. Others, including ENGINEERING, have said that the shortage of labour will effectively stop the present trend towards a higher standard of living unless everyone is able to produce a deal more. Any reduction we can make in industry's requirements of office workers, machine minders and labourers who move materials through the shops will be a step in the right direction.

An authoritative voice on the other side of the Atlantic, that of Mr. Peter Drucker, has recently made an important contribution on the subject, as outlined in the next note. The positive aspects of automation he underlines are those the trade unions and Parliament should examine with particular thoroughness and on which too much light cannot be thrown.

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....and Hopes

Mr. Peter Drucker does not mince his words on the subject of automation in his analysis of its impact on management practice (*The Practice of Management*, Heinemann, London, 1955): "The popular belief that the new technology will replace human labour by robots is utterly false." In his view the number of people required by industry will be increased, as it was by the spread of mass-production in the first half of the present century. The demand for highly skilled and highly trained people created by the new techniques will be such that the major obstacle to their rapid spread "will almost certainly be the lack, in every country, of enough trained men."

Mr. Drucker makes two most important other points: first, the adoption of automatic processes over a wide field of industry will tend to reduce very substantially the cost of manufactured articles, thereby increasing the standard of living of the countries concerned: "There can be little doubt that the industrial country that first understands automation and first applies it systematically will lead in productivity and wealth during the second half of the 20th Century, just as the United States, through understanding and applying mass production, came to lead during the first half". The second point is that automatic processes can only become economic if the volume of output is kept steady: "Under automation, it is a major responsibility of management both in mass-production and in process production to maintain a steadier level of economic activity and to prevent extreme economic fluctuations, whether of boom or depression."

The point concerning the stability of output, and therefore of employment, is well worth examining closely (the performance and efforts of the oil industry in this direction are quoted in this context), as also is Mr. Drucker's contention that companies cannot afford to disband a work force trained both in skill and theoretical understanding as "it can normally only be created within the company and with years of effort."

Such remarks, by a man who all his life has been in close touch with American industry, cannot lightly be dismissed. But they require careful analysis in the British industrial and social context.

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Working Pensioners

The news given last month by Mr. Osbert Peake, Minister of Pensions and National Insurance, that the National Insurance Advisory Committee should consider whether there should be adjustments in the earnings limit for pensions, has now been followed by the Committee's announcement that they were ready to consider representations on the subject. They will not be concerned with the fact that the Ministry will not pay out until retirement if this is postponed beyond the statutory limit. It is with the appropriateness of the reductions in payments which begin when a pensioner's earnings exceed 40*s*. a week, or that of a widowed mother 60*s*. a week (a reduction of a shilling for each complete shilling of the excess). There are other similar reductions which apply to unemployment benefit or sickness benefit.

Viewed in relation to the cost of living, or to the average earnings for the country as a whole, the limits at which reductions come into force are so obviously out of proportion that a detailed inquiry by a committee would seem superfluous. But the problems of an ageing population are upon us, and some purposeful thinking is urgently required. There is certainly no excuse in so prosperous an age for imposing hardships on a growing section of the community, nor is it in the country's interest to provide old people with an incentive not to work when they might feel able to do so.